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ABSTRACT

This is the second of a three-volume set containing papers related to the theme of science and technology education. This volume relates technology education and science-technology-society (STS) to the quality of life with respect to: (1) the impact on everyday life situations; (2) decisions a responsible citizen has to make when dealing with controversial societal issues; and (3) the impact on future careers and the potential impact on the future products of scientific and technological research on careers. The symposium consisted of three working groups dealing with these areas from the point of view of science education; technology education; and science, technology and society (STS). (ML)

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Volume 2

Technology Education
Science-Technology-Society

Kurt Riquarts (ed.)

Science and Technology Education and the Quality of Life

Volume 2

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Science and Technology Education and the Quality of Life

Volume 2

Technology Education
Science-Technology-Society

Papers submitted to the 4th International
Symposium on World Trends in Science and
Technology Education
Kiel, 4 – 12 August 1987

4

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Foreword

This symposium will be the fourth in a series initiated in Halifax (Canada, August 1979), continued in Nottingham (Great Britain, July 1982) and Brisbane (Australia, December 1984).

This two-volume publication contains 104 papers to be presented at the 4th International Symposium on World Trends in Science and Technology Education, organized by the Institute for Science Education (IPN), Kiel, Federal Republic of Germany, in cooperation with the International Organization for Science and Technology Education (IOSTE) and the Pädagogische Hochschule Kiel.

As proposed by IPN and agreed on by the IOSTE commitee and the General Assembly at the Brisbane symposium the theme of the 4th symposium will be :

Science and technology education and the quality of life.

Science and technology education will be related to the quality of life with respect to

(1) the impact on everyday life situations

(2) desicions a responsible citizen has to make when dealing with (controversial) societal issues

(3) the impact on future careers, and the potential impact on the (future) products of scientific and technological research on careers.

Three working groups will deal with these areas from the point of view of

(1) science education

(2) technology education

(3) science, technology and society (STS).

According to this structure all the papers were categorized and each was assigned to

(1) one of the groups

(2) the content area 1-3.

Obviously, this large number of papers cannot be read at the symposium. As pointed out in the invitation the presentation of the papers will be through discussion in the working groups.

Volume 1 contains the papers relevant to the theme of Science Education, volume 2 those relating to Technology Education and Science-Technology-Society (STS).

On behalf of the Organizing Committee I would like to thank the participants of the two preparatory meetings held at IPN, Kiel (October 1985 and April 1987)

- Glen Aikenhead (Canada)
- Geoffrey Harrison (Great Britain)
- Jayshree Mehta (India)
- Jacques v. Trommel (Netherlands)
- George I. Za'rour (Lebanon)

for their valuable advice and readiness to discuss the submitted and accepted papers in detail and group them according to the set outlines.

Furthermore, the Organizing Committee would like to thank the following for their substantial financial support :

-Institute for Science Education (IPN), Kiel

-United Nations Educational Scientific and Cultural Organization (UNESCO), Paris

-German Foundations for International Development (DSE), Bonn

The symposium proceedings will be published by IPN and are to include :

-plenary speeches

-findings of the workshops

-synopsis of the poster sessions and exhibitions

-findings of the working groups

-general recommendations

IPN is proud to have been invited to host this symposium and to contribute to a genuinely international occasion.

Kurt Riquarts
Symposium Chairman

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PUPILS' LACK OF SOPHISTICATION LEADING TO APPLICATIONS OF UNAPPLICABLE PRINCIPLES IN AGROTECHNICAL CONTEXTS

Amos Dreyfus (The Hebrew University of Jerusalem, Israel)

INTRODUCTION

A technological context, from the point of view of the science educator, is a situation in which a) a problem is to be solved by technological methods; b) the understanding of the parameters of the problem, as well as of its solution, depends on the recognition of the applicability of scientific principles. (Jungwirth,1966) The contribution of technology to science education can therefore be invaluable ,in the sense that it provides opportunities to learn scientific concepts and principles in meaningful contexts (Dreyfus, 1987).

However, when given such opportunities, pupils often perform well below the expectations of the teacher. Their concepts may be "poorly differentiated", because naive knowledge "serves the student satisfactorily" and therefore interferes with the learning of scientific knowledge (Champagne, Gunstone and Klopfer, 1983). "Low-meaningful students" even when showing no "intellectual inability to employ the logical the logical procedures which underlie solutions to problems", do tend to manipulate "different, and erroneous conceptual information" (Stewart,1985). Furthermore, children seem to be able to reach the conclusions desired by he teacher, while using the wrong conceptions (Eaton, Anderson and Smith, 1983).

The "Science of Life and Agriculture" curriculum, developed recently in Israel for rural and agricultural secondary schools (10th to 12th grade) is an agro-biological curriculum. One of its main objectives is the ability to recognise the relevance of scientific concepts and principles in agricultural situations (Feinstein and Blum, 1983). Special emphasis was therefore put on the evaluation of the achievements of the learners, concerning this specific objective . So far, evaluation has been focused on 10th. grade pupils, i.e. pupils whose scientific repertoire (chemistry, physics) is still rudimentary. In one of the tests, the pupils were confronted with statements or open questions to which they were expected to respond by using concepts and principles they had been taught. Later, samples of pupils were also interviewed. It was found that only a minority responded in the expected way (Dreyfus, 1986). One of the main patterns of response , specially relevant to the application of principles, will be described below.

PRINCIPLES AS KEYS

A lock and key model can be used to describe the appropriateness of a principle to a situation (the term situation is used to describe any set of conditions which requires clarification, explanation, or solution). A principle (the key) "fits" a situation (the lock) if its dents fit the shape of the situation. The dents are the attributes of the principle, of the concepts it comprises.

If any of the dents does not fit, then the key cannot be turned i.e. the principle cannot be applied to the specific situation.

If a pupil is not aware of the fact that the dent -with which he is familiar- does not fit, then he has formed a misconception about the shape of the dent (i.e at the level of the principle to be applied),or of the situation, or both.

However, when we adapt the level of teaching of concepts and principles to the intellectual and scientific level of given pupils, we usually teach a simplified version of the principle : we voluntarily omit certain dents (certain attributes) which are considered to be beyond reach of the pupils.

The "simple keys" may then be introduced into some non-intended locks, because the dents which could prevent their introduction, are missing .The pupils then use, unpredictably, "irrelevant keys". They remain unaware of the fact that the key does not open the door, because, dealing with theoretical situations, they have no opportunity to actually try to open it; they are just required to recognise the applicability of the principle (the possibility to introduce it into the lock).

Wrong keys can be used by pupils at various levels of irrelevance. This will be shown by the very characteristic following examples, selected from one of the tests administered during the evaluation of one of the units of "Sciences of Life and Agriculture",. The pupils were required to explain the meaning of the statement "Ruminants do not compete with men for food". The answers were expected to refer to the fact that ruminants, owing to the population of micro- organisms in their rumen, are able to survive on diets in which a) cellulose, which cannot be utilised by the human organism, is the main (or sole) source of carbohydrates; b) essential (to the human organism) amino acids are lacking. These diets consist of foods which are unfit for human use. Topics a) and b), regarded to be essential knowledge, had been treated explicitely by the teachers. However, the test was, on purpose, administered a few months after the teaching of the unit. As a result the desired answer had become less than self-evident to the pupils, who were compelled to search for an answer "somewhere in their knowledge" (as expressed vividly by one of them). A minority found the right principles and only a part of this minority related them correctly to the situation. The majority tried something else ("other keys").

WRONG KEYS IN THE LOCKS

The most representative and common types of failure to perform according to expectations can be classified, as will be shown below, according to three factors:
a) The "missing dent(s)" and the area of knowledge to which it (they) belong(s);
b) What caused the "dent" to be missing; c) The level of sophistication which, had it been reached by the pupils, might have prevented the error.

TYPE A:
" When they are hungry, ruminants can ruminate and therefore do not need any supplement of food, so that they do not compete with man."
This is a complete misconception: ruminants while ruminating, "eat again the same food", implying that the body can profit twice of one portion of food.
The missing dent belongs to that body of non specific general knowledge which is regarded to be a prerequisite to the learning of the topic under consideration (and is thus more inclusive), namely conservation of matter and energy : a given amount of food can yield only a given amount of metabolizable materials or energy.

The pupils who gave this type of answer did not establish the link with the right concept. It can be seen that they "imported" an unexpected concept (rumination) into the problem. They "succeeded " in doing so because they were naively unaware of the scientific absurdity of their explanation, because of the missing dent. The missing of the dent, in turn, was not uncovered by the teachers, because the pupils had not been put in situations where they might have reached a state of conflict while using wrongly the concept of rumination. It can therefore be concluded that the "crucial dent" was missing because the teaching had stressed only the specific aspects of rumination (adaptation, anatomy) and had not dealt with what rumination is not, (most of the emphases having been put on other and more essential topics).
At the " level of sophistication which may have prevented the misconception", the pupils would have had to cope with information on the composition of food before and after rumination, and to have reached a better understanding of the significance of rumination, beyond the physical aspects. This, however, as stressed above, had not been regarded to be essential knowledge at this stage of the pupils' scientific education.

TYPE B:
"It means that human food is not suitable for ruminants. In most cases ruminants can eat only residues from human food (the original term used here by the pupils means " rubbish, things which are thrown away by men") or things which human beings cannot eat (straw, grass, orange peels etc)."

The respondents in this case had used an oversimplified , but partially correct principle, which was , this time, directly related to the topic under consideration:

The over-simplified principle : The food of ruminants is different from human food; digestion of ruminants is different from human digestion

The missing dent: the ruminants, in their intestine, digest exactly like other vegetarian mammals, and therefore can digest human vegetal food. Also, man does eat grass (lettuce,etc).

Interviews showed that the missing dent was truly missing: the respondants claimed that they did not know the facts about the intestine of the ruminants. According to them, the cause of their failure to "understand the subject" was easy to spot:

Origin : Teaching stresses very much the difference between ruminant and human digestion and under-emphasises the similarities. Teachers remain unaware of pupils' misunderstanding of the biological process.

Level of sophistication not reached, which may have prevented the error: the fate of food after leaving the rumen, in terms of nutritional efficiency; nutritional efficiency of various feeds .

It can been seen that the missing dent had brought about a curious misconception, namely that it is the ruminants who are the ones who can digest less efficiently than human beings. This contradicts school knowledge (ruminants can utilise cellulose , which men cannot), but is consonant with personal knowledge (cattle cannot eat meat); again, the respondents personal knowledge had not been challenged by the desired scientific knowledge.

Did the pupils oversimplify the principle in spite of the efforts of the teachers? Did the teachers unconsciously present an oversimplified form of the principle or did they do it on purpose ? The interesting fact remains that from the point of view of the respondents, the principle, as they perceived it, did fit the problem, so that the explanation they had suggested appeared to them as perfectly reasonable.

In the first example, the pupils had "imported" the unexpected principle from the prerequisites and, in the second case, from within the topic itself; in the next example, they imported it from far away.

TYPE C:

"At the beginning cattle were eating everything but man taught them to eat only certain foods"

or other formulations of the same idea, such as:

" At the beginning cattle were eating everything but men took all the good food and they had to content themselves with straw, etc" or "men gave them only certain foods and they became used to them".

That kind of theory is based on the idea that, by means of artificial selection and breeding, farmers had succeeded in developing ruminants who were hereditarily adapted to the kind of food "they eat nowadays".

The over-simplified principle applied in such explanations was: that, since men can develop desired hereditary traits in animals and plants, (which in itself is correct), it follows that they can develop any trait in any animal (incorrect). The principles of breeding are not treated during the teaching of ruminant nutrition, because they seem to be far remote from the subject. However, the evolutionary aspects of ruminant nutrition are often treated at length.
The missing dents were numerous, most of them related to what it would take to develop an animal with a digestive system as complex as that of the ruminants; also that if, since the beginning of the domestication of cattle, man had indeed produced a "new animal", there should be some traces of the ancestors of this new animal; concerning the pupils who thought that the ruminants were already existing, and that men only taught them to content themselves with straw: what would have been the evolutionary status of these first ruminants?
The origin: school and other sources of knowledge concerning breeding and artificial selection. Teaching stresses the points of similarity between natural and artificial selection, but not the differences. Furthermore, the private as well as the formal school experience of the rural pupils (in a country of ultra-modern agriculture) seemed to impute to agricultural research a practically illimited potential.

Level of sophistication not reached, which might have prevented the unsound use of the principle: a deeper understanding of the the factors, the mechanisms and the complexity of breeding of desired types of organisms. Historical knowledge about the development of the civilisation (the time factor). Comparison between evolution and breeding.

At that stage of their studies (10th grade), the pupils, for obvious reasons, had encountered only very simplified, adapted to their scientific level, versions of the principles of genetics and of applied genetics (breeding). There was nothing in these versions, which could have prevented them from applying them to the problem they were confronted with, but neither did them imply any encouragement to do so. The problem of digestion and the principles of breeding had not been considered to belong to the same area of the curriculum or to be interconnected and therefore, justifiably enough, had not been treated in conjunction. The "missing dents" were beyond reach of the pupils. It just so happened that the pupils, while suggesting a perfectly reasonable solution (from their point of view), applied erroneously, a completely unapplicable principlo (from the point of view of the teachers). For reasons of space this paper has focused on only one item of the questionnaire.However, similar "misapplications" occurred in most of the cases where the pupils had been trying to link concrete phenomena with abstract principles (mainly, in this study, those referring to biochemical and metabolic processes and components).

CONCLUSIONS

It is fairly obvious that the level at which scientific principles are taught must be adapted to the scientific level of the learner, and that, accordingly, school science consists only of simplified versions of these principles. On the other hand, these versions may turn out ot have been over-simplified, in the sense that the pupils remain unable to use them accurately at the required level. These "blurred representations" of the principles lack the crucial attributes which confer upon them their specific meanings. Pupils then tend to ascribe to the principles meanings and implications which they do not possess. Such erroneous perceptions of the principles are difficult to diagnose because pupils display them only while irrelevantly using the principles, and irrelevant use is by definition unpredictable. This was clearly demonstrated in this study. The written tests and the interviews showed that failure to identify the applicable principle did not necessarily imply ignorance or serious misconceptions . To some pupils the principle was just momentarily unavailable, and others did not spot its applicability to the situation. It is about other principles that unsuspected misconceptions were uncovered . The pupils had not actually been expected to refer to them, and they were in fact hardly relevant to the subject matter under consideration. Still, the pupils perceived their versions as relevant and applicable.

The science teacher, as shown in this study, are daily confronted with this problem: they can teach pupils which principle to apply, and where, when and how to apply it. But they cannot teach which principles not to apply, because of the unpredictability of such misapplications, of the variety of their sources and of their great quantity.

Teachers must therefore create situations in which pupils are given opportunities to make erroneous applications of unexpected principles. This is actually the only way to diagnose some unsuspected misconceptions. However, teachers normally find it difficult to design such educational activities in sufficient quantities.

Technology minded curricula, by their very applicative nature, consist of such activities, in which the pupils are required to put theory into practice. In this type of curriculum, the learners have opportunities to actually make use of the concepts and principles they are acquiring, and to contrast the "official" versions with their personal perceptions. While doing so they provide the teacher with opportunities to diagnose not only if the learners use accurately a given principle, but also, what they do when this is not the case.

Technology oriented scientific curricula, such as the one referred to here, in which scientific concepts can be meaningfully used and applied, may satisfy the needs of the pupils as well as those of the teachers.

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I. PRE-UNIVERSITY EDUCATIONAL SYSTEM IN ISRAEL

a) Compulsory kindergarten - age 5.

b) Elementary school
  Type 1: eight grades (age 6-14) OR
  Type 2: six grades (age 6-12)

c) Secondary school
  Type 1, following elementary school type 1:
    Grades 9-12 (age 15-18)
  Type 2, following elementary school type 2:
    Grades 7-9 (age 13-15) - intermediate (or junior)
AND - Grades 10-12 (age 16-18) - upper (or senior).

Compulsory Education: age 5-16.
The educational system includes State schools and State religious schools; the main types of secondary schools besides regular secondary schools, are: comprehensive, rural, agricultural, and technological. Technological education is given in technological and in comprehensive secondary schools.

II. The paper is relevant to science education as a whole, but has special implications for technological education. The study was conducted under a grant from the Department of Rural Education, as part of the development of a new Agrobiological Curriculum, which has a strong S.T.S. slant.

III. AUTOBIOGRAPHICAL NOTES.

Born Paris, 1933. In Israel since 1951. B.Sc. Agr. and P.G.Certificate of Education, biology and agriculture, (The Hebrew University of Jerusalem), 1964 ; M.Sc.Agr. (The Hebrew University of Jerusalem), 1967; Ph.D (Science Teaching, The Hebrew University of Jerusalem), 1976. Teacher of biology and agriculture in secondary schools for 10 years. Now Senior Lecturer in agricultural and science education, The Hebrew University of Jerusalem. Senior Investigator at the Israel Science Teaching Center. Head of a project of development and evaluation of an agrobiological curriculum designed for rural and agricultural schools. Member of several national committees concerning secondary and scientific education. Papers in various professional journals, mainly in U.S. and Europe.

SOME DEVELOPMENTS IN TECHNOLOGY EDUCATION IN AUSTRALIA

Ken Eckersall (Australia)

This paper considers ways of fostering young peoples' learning about technology and its influences on their everyday life, engaging them in school activities that promote their 'technical thinking and acting' abilities, and developing their decision-making capacities about the benefits or otherwise of a particular technology. It outlines the report, Technology Education (1986), which details a research and development project conducted in Victoria, Australia, by Hawthorn Institute of Education.

Project aims

Among other things, the project aimed to:

- define the nature and purpose of technology education;

- elaborate its nature and purpose in post-primary school contexts, using three potential curriculum emphases - technology education in practical studies subjects, technology education in all subjects, and technology education as an emphasis in specific subjects;

- set up, in post-primary schools, case studies which exemplify these three curriculum emphases or any other, initiating opportunities for the professional development of participating personnel;

- and provide a report which could act as a guide for teachers/administrators/curriculum developers as well as indicate professional development and facilities planning implications.

Literature survey

Relevant literature from Australian and overseas sources was surveyed for information on defining technology and specifying, developing and implementing technology education in schools; also exhaustive analysis of curriculum literature was carried out (it was recognised that considerations on technology education often leave out the broad curriculum dimension):

- discussion was developed on four curriculum orientations (called in the project) curriculum as a technology, curiculum as cognitive process, the humanistic curriculum, and curriculum as social relevance-reconstruction;

- discussion was developed on a curriculum development framework, a curriculum development system, a model for effective learning in technology education (problem solving), and the teachers' role in using the model;

. and some general guidelines for technology education were outlined.

Operational definition of, and some criteria for, technology education

The guidelines drawn from literature sources (and confirmed by participant observations) provided the following operational definition of technology education: technology education is an integrated study, capable of being embodied in science, practical subjects, environmental studies and arts and crafts, but having special links with science; such an education will engage students in problem solving (including problem clarification, proposal of solutions, assessment of appropriateness, implementation of selected solution, and evaluation) as well as applying technical skills, i.e. technical thinking and acting (including materials appreciation and using drawings, measuring devices, tools, equipment and machines) and will provide opportunities for students to reflect on the social consequences of the technology with which they are involved.

Further, the project processes provided the following technology education criteria.

Technology education should have as a goal the development of each student as one who:

. identifies technological problems or issues as well as issues in which technology is in question;

. evaluates various claims concerning the alleged benefits of technology in the light of economic, moral and social criteria;

. plans or suggests ways of planning technology consistent with an acknowledged concept of a good society;

. is capable of making things or of testing and implementing technology in practical situations.

Activities in technology education should be selected on the basis that one activity is more worthwhile than another if it:

. utilises concrete experience abilities, i.e.
- involves students with 'real world' situations, objects, materials,
- involves students in identifying problems or issues from various perspectives or points of view,
- involves access to ideas, processes, activities or situations not otherwise encountered by students,
- places students in active roles throughout,
- is relevant to the expressed purposes of students themselves;

. utilises reflective observation abilities, i.e.
- involves a risk of success or failure, a balance between hope of success and fear of failure,
- requires students to reflect on their own situation, choices, plans, and actions and in terms of personal values, feelings, beliefs and experiences;

. utilises abstract conceptualisation abilities, i.e.
- involves the integration of studies, ideas or materials that are conventionally separated,
- permits students to make informed choices in planning and in carrying out these plans,
- involves the application and mastery of meaningful rules or standards,
- can be completed successfully in different ways;

. utilises active experimentation abilities, i.e.
- explores the consequences of existing activities or proposed activities and encourages the making of technical and value judgements regarding plans, events, and outcomes,
- involves students in reworking or improving their initial efforts,
- involves students in examining or applying in a new situation an idea, principle or skill which has been previously studied or developed,
- contributes to a balanced overall course of study (e.g. of materials, processes, problems, social situations).

In technology education, teaching and learning should be regarded as interrelated activities in which experience, reflection, planning and experimentation all have prominent places.

Case studies

The project set-up case studies involving participation of Hawthorn Institute of Education personnel in a sample of Victorian institutions implementing technology education. These dealt with the following (local names are cited for identification purposes):

. establishment of a Technology Resources Area as a resource facility for all subjects in the Years 7-12 curricula at Cheltenham High School;

. implementation of a design-based approach to teaching woodwork, incorporating problem-solving methods, for Year 7 students at St Albans Technical School;

. development of a discrete practical arts subject, technology, for students in Years 8 and 9 at St Helena Post-primary School;

. and implementation of a materials study, art and technology, for art trainee teachers at Hawthorn Institute.

Conclusions were drawn on the respective case studies, supplying information for each group concerned (ownership of the respective studies by the participating schools was emphasised in the interests of good collaboration).

Also broad implications were raised that:

- systematic evaluation of technology education programs in schools is needed;

- technology education initiatives should be planned within a total school context rather than piecemeal;

- external back-up support appears to be necessary for developing substantial technology education activities in schools;

- a variety of technology education approaches are likely to be developed in the future, indicating the need for flexible curriculum, personnel and facilities planning;

- and there is a need for relevant pre-service teacher training and professional development programs.

(Videotapes and slides depicting technology education student/teacher activities in the various venues will be shown.)

Overall conclusions

Overall conclusions drawn in the project were:

- every subject in the school curricula needs to address technology education (the art and technology materials study project was a case in point, also novel examples were seen in the Cheltenham High School Year 9 program, such as in history where students made Sumerian mud-brick houses using grass reinforced miniature bricks; in science where class members used appropriate computer software to design an energy-efficient house; and in geography where students recorded temperature readings by wet and dry bulb thermometers and discussed implications for clothing people suitably for working in the Antarctic; a further example is the slide set, 'From the camp oven to the microwave: a history of technology in the Australian kitchen' (or a 'potted Australian history', that was developed for the UNESCO Pilot Project [this will be shown]);

- technology education should be integrated through the school curricula (this was contentious for the St Helena Post-primary group who argued for technology as a discrete subject aimed at developing students' concepts about, and understading of, technology through participating in practical studies based on units such as structures, materials properties, robotics, polymers, mechanics, lasers and fibre optics;

- recommended technology education approaches may be contrasted with regular practices as in practical studies in post-primary schools (for example, the case study in woodwork at St Albans Technical School identified real tension amongst teachers over the emphases in the design-based program on exploration and discovery learning, learning about properties of materials, and learning requisite skills as they are needed, against emphases associated with traditional woodwork programs, such as training in tool skills and teaching 'correct' methods);

- generally, post-primary school teachers and students have only limited experience in using investigative, analytical, experimental and problem-solving approaches);

- teachers seem to afford considerable importance to technology in, and across, most curriculum areas;

- there is an apparent role in post-primary schools for a person to co-ordinate technology education (notwithstanding anything said above, in the actual school situation some individual has to be an 'advocate' and also responsible for time-tabling, ordering materials, maintenance of equipment, etc.);

- systematic professional development is an essential part of developing and implementing technology education (a particular aspect is training teachers in the correct and safe handling of new-technology tools, materials, equipment, etc.);

- technology education requires appropriate school facilities;

- and existing policies for devolving power in the Victorian education system have the potential for fostering technology education in schools.

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Context

In the Australian Federal structure the States are responsible for education, so there are some variations between systems.

Briefly, in Victoria, since the beginning of 1987 sectors have been:

- primary - Years Prep-6 (5-11 year olds);

. post-primary - Years 7-12 (previously Victoria had a dual secondary arrangement, with high schools and technical schools) (12-16 year olds);

. tertiary - adult: technical and further education (TAFE); colleges of advanced education (CAEs); universities.

The mode of assessment used for university entrance is the part external/internal examination for the Victorian Certificate of Education (VCE), which is taken over two years (Years 11 and 12). (Prior to 1987, university entrance was per the Higher School Certificate Year 12 examination.)

The context of this paper is the Victorian post-primary sector. In some ways the discussion is also relevant to post-primary education in other Australian states, notably South Australia.

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Professional Experience: Industrial - 10 years printing industry; Teaching - 16 years printing trades and humanities (TAFE), 4 years Principles and Methods of Teaching (tertiary); Research - 5 years.

Publications: Thirty publications mainly dealing with printing education, history of technical education, apprenticeship, technological change and technology education.

EDUCATIONAL FRAMEWORK FOR SCHOOL TECHNOLOGY

Peter Edwards (Trent Polytechnic, Nottingham,
Great Britain)

This paper aims to place in context School Technology within the current educational framework. The information is drawn from sources with considerable assumed influence. It is set out in the following format:

1 Historical Developments
2 National Policy and Thinking
3 A Case for School Technology
4 Current Practice.

Technology in schools means different things to different people!

Technology - a definition

> "To enable all children to become involved in at least some part or parts of the technological design process.
>
> To develop in all children a general understanding, an appreciation of and sympathy for scientific and technological developments (a purpose).
>
> To help all children to increase their personal resources of applicable knowledge and skill".
>
> Ref. School Technology Forum.

1 Historic Developments

The first major steps in developing the concepts of School Technology were taken as a result of work done by a small but significant number of highly motivated, innovative teachers. Such steps included the publication of "Engineering among the Schools" by Page, "A School Approach to Technology" by Porter and the commencement of Project Technology by the Schools Council. All of these events taking place before the end of the 1960s. From those earliest of developments questions were being asked about the meaning of Technology in schools. The School Technology Forum (STF) Working Paper No 1 (1973) refers to Technology as being -

> ". . . . . . different from traditional school subjects in that it requires and generates many links outside school and that it demands teachers who having a real understanding of its aims and philosophy, have the ability to foster in children the type and quality of thought and imaginative approach of the engineer and applied scientist".

At the same time Technology was being introduced to the curriculum by schools and teachers as no more than a traditional subject area. In so doing similar methods of teaching to those already in use within well established subjects were employed. Hence basic misunderstanding commenced and a dichotomy of perception was born.

This perhaps is best resolved by first accepting that Technology does differ from other subjects as suggested, but that this apparent imcompatibility of existence masks the true potential of Technology. This potential being exposed by seeing Technology's relationship with other subjects.

"Technology and subjects studied at school may be related through influence or through resource. Subjects may influence and be influenced by Technology. Equally subjects provide resources for Technology and are provided with resources by Technology".

Ref. STF Working Paper 3 (1977)

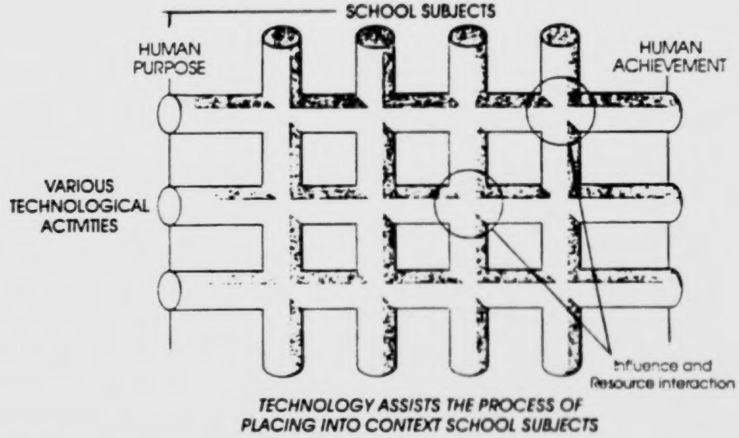

SCHOOL SUBJECTS
HUMAN PURPOSE
HUMAN ACHIEVEMENT
VARIOUS TECHNOLOGICAL ACTIVITIES
Influence and Resource interaction
TECHNOLOGY ASSISTS THE PROCESS OF PLACING INTO CONTEXT SCHOOL SUBJECTS

Fig 1.

It can already be appreciated that Technology, as with many other curriculum areas, should not be perceived as discrete. However, Technology is seen by many as being nothing more than advanced and sophisticated engineering, or the sum of civil, electrical and mechanical engineering and the danger exists that this will be the perception of Technology by those most influential in its implementation - the teachers.

If Technology is not this tightly defined curriculum area and is more of an integrator then we need to be clear as to the nature of its integrative features. If this is achieved, we must then place School Technology within the context of Government policy as described in the White Paper, "Better Schools" (HMSO 1985) and current education thinking by Her Majesty's Inspectorate through their paper, "The Curriculum from 5 to 16" (HMSO 1985).

2 National Policy and Thinking

"Better Schools" states that the curriculum offered to every pupil whether at an ordinary school or a special school should be:-

Broad:	It should introduce pupils to a wide range of knowledge, understanding and skills.
Balanced:	Each part should be allotted sufficient time to make its special contribution, but not so much that it squeezes out other essential parts.
Relevant:	Subjects should be taught so as to bring out their application to the pupil's own experience and to adult life and to give due emphasis to practical aspects.
Differentiated:	What is taught and how is it taught needs to be matched to pupils' abilities and aptitudes.
Progressive:	There should be a continuum between the various phases of education. The curriculum through primary and first three years of secondary should be largely common to all pupils. The activities should be so designed as to provide pupils with the opportunity to progress naturally.

These statements are set against Government intention that **all pupils** need to continue with

"English
Mathematics
A Broad Science
Elements of Humanities
Values and the Foundation of British Society
Economic Awareness
Practical and Technological work in a number of subjects
Foreign Language-continued for most pupils".

The place of Religious Education is governed by law - the Government does not intend to change this.

The inclusion of **Practical and Technological work in a number of subjects** is further reinforced by HMI thinking which is that:-

> "The curriculum of **all schools** would involve pupils in each of the following areas of learning and experience:-
>
> Aesthetic and Creative
> Human and Social
> Linguistic and Literary
> Mathematical
> Moral
> Physical
> Scientific
> Spiritual
> **Technological**

It is true to say that all of these areas of learning and experience form subsets of developed human capability. An understanding member of, and contributor to society, will have, within his or her capability, capacities to respond in a balanced manner to given situations. This is not to say that each of these capacities will be developed to an equal extent or even called upon in equal quantity.

There will be a need, however, for the areas of learning and experience to be integrated into personal capability and characterised by an individual's perception of and response to need.

Two people, faced with the same situation, will almost certainly respond differently. This is not to say that either one of them is any more correct. One can say that if these two people have developed senses through the areas of learning and experience then each response should be valid.

If one looks more closely at the characteristics of human capability one can see that, in differing circumstances, each of the areas under consideration can assume a different priority in any individual response to circumstances faced. However it would be wrong to think that these capacities are discrete or that any one of them is any more important than another.

A person studying aspects of science may be expected to respond with a science bias. It may also be true that response may be far from being scientific. However, it will almost certainly be so that any response within that scientific context will involve a good deal of communication, in both verbal and graphic form. It could involve a personal judgement and may also refer to the social implications of any decisions taken or made.

Thus we can see that each of the areas of learning and experience can be dominant or subordinate but are certainly interdependent within the context of human capability. Each can subsume or be subsumed by the other.

Technology is clearly identified as not only having a place within the learning and experience of a curriculum but it is policy that pupils should experience technological activity in a number of subject areas, not least that of science.

> "The Curriculum from 5 to 16" then refers to the elements of learning and provides a checklist".

"Knowledge:	Knowledge continues to expand rapidly. Schools need to be highly selective when deciding what is to be taught.
Concepts:	Generalisations usually arrived at through a process of abstraction from a number of discrete examples. They enable pupils to classify and organise knowledge and experience and to predict, eg temperature, energy.
Skills:	The capacity or competence to perform a task.
Attitudes:	Overt expression, in a variety of situations, of values and personal qualities, to which they are closely related".

These elements of learning are seen as inseparable from the context of the areas of learning and experience. However, the four elements, it is suggested, should feature in and be developed through all nine areas described previously.

3 A Case for School Technology

The Assessment and Performance Unit (APU) studied work in "Technology" across CDT and Science and concluded that:-

> "Technological capability is seen as that which enables a person to enrich the quality of life by using technological skills, knowledge and value judgments in the development of man-made environments and man-made things".

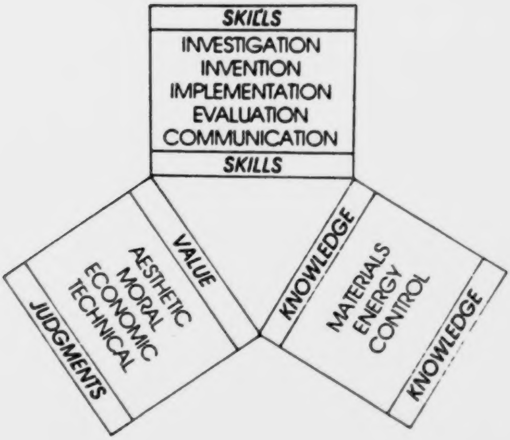


Fig 2.

This statement, however, presupposes that all pursuits will be toward enhancing the quality of life. For this to be realised there would have to be, in all, a developed sense of human values which is appreciative of good or ill intent. Whilst this capacity may in fact be fostered we cannot assume that all outcomes developed through individual value judgements, particularly moral judgements, will be targeted for the good of all.

As can be seen the APU view of technological capability expresses the same elements as HMI deem essential to wholesome education. HMI also indicate that these elements should be developed through and in all the areas of learning and experience. We must conclude that technological activity should be an expression of homogeneous education, or that the essential characteristics of technology, as a process for developing individual capability, (out of individual need), should be used throughout the areas of learning and experience, whatever the local interpretation of structure and organisation may be.

> "Whatever the arrangements for cross-curricular issues they should not be left to chance or to individual initiatives: their place needs to be assured through consultation, be consistent with the general framework adopted by the school and be recorded in schemes fo work which indicates the progression to be expected".
> Ref. Curriculum from 5 to 16.

This more than suggests that method of teaching and learning is at least as important as that which is to be taught or learnt. We know that it is policy that school education should do much more to promote enterprise and adaptability and to fit young people for working life in a technological age through the opportunity for oral discussion and solving practical problems. Also that an HMI view is:

> "Learning about Technology and its historical and social consequences and exploring the opportunities to apply scientific principles that involvement with it makes possible, have long featured in the work of schools. Such work should continue and if anything be increased in scale and range. But work of that kind does not in itself make up a technological area of learning and experience sufficiently delineated and comprehensive to stand alongside the other more firmly established areas that should feature in a broad curriculum. The study of the impact of Technology and its social and environmental 'spin-offs' however interesting, is no substitute for active involvement in the process itself. All pupils throughout the 5 to 16 period should be so involved. The essence of Technology lies in the process of bringing about change or exercising control over the environment".

This gives positive reinforcement to the view that Technology is not just advanced knowledge, but is about acknowledging a need and applying ones own knowledge and experience to satisfy that need. In so doing, as suggested, a host of educational benefits to the individuals so involved is accrued.

In accepting that needs exist in all strands of activity we are immediately led to conclude that Technology must by definition be cross-curricular and even integrative in nature.

"In Place of Confusion" by Paul Black and Geoffrey Harrison pursues those concepts further and argues that in order to educate our children for ". . . . . those human activities which bring about change, enhance the environment, create wealth, produce food and entertainment and generally get things done". We need to develop their:-

> "Application of personal driving qualities such as determination, enterprise, resourcefulness:
>
> personal innovative powers of imagination, intuition and invention:
>
> powers of observation and perception:
>
> willingness to make decisions based both on logic and on intuition:
>
> sensitivity to the needs being served, to the possible consequences, benign or harmful, of alternative solutions, to the values being pursued".

This model concentrates on the outcomes of action in certain activities. It infers that the personal qualities listed above are an intrinsic requirement of 'success' in those activities. Whilst a person involved in, for instance, designing and making a garden shed or composing a symphony, will set, and hopefully satisfy, criteria developed from his or her own values, doubt must exist as to whether all of the characteristics mentioned will result simply from involvement in the activity. There remains a need to seek ways of identifying the manner and magnitude of the personal driving qualities that are developed by involvement in such activities. (Externalising the internal feelings being developed through the activity).

We should ensure that young people, so involved, acknowledge these developing internal attributes and remain aware that they are there as a resource to be drawn upon and developed further through present and future technological activity. (The internal appreciation of the experiences and the effect of them for present and future use - as a resource).

Technology therefore demands that for young people to become fully capable by means of education, then that education should not only give wholesome opportunity in the resources of knowledge, skills and experience, but should also call for action in demonstrating these elements.

So the pattern emerges that Technology has at its core human capacities that, when they are brought together by interaction, provide individuals with real opportunity to change, and hopefully enhance, the man made world.

This Task - Action - Capability model of Technology suggests that staff will need to become more involved across subject boundaries as the pupils pursue activities that call for expression in and from more than one traditional area of the curriculum.

More recently the STF published its commentary on "The Curriculum from 5 to 16" and its theme throughout is that Technology exists in all aspects of curriculum activity by means of three dimensions of technological capability.

"Purpose:	understanding of human needs and values
Process:	competence in the intellectual and physical skills of problem solving and produce development to meet such needs
Resources:	ability to acquire and call on resources of applicable knowledge physical and intellectual skills and experience and personal qualities needed to apply problem solving skills and the solution of human problems".

Whilst recognition is given to the components of a curriculum and their value to the pupils, this commentary demonstrates the inextricable links between traditional subjects and technology and vice-versa. This being an extension of the interaction alluded to in Fig 1.

The process skills referred to can be drawn on in various forms and by using a number of strategies. They may be unstructured, intuitive or heuristic, whilst they could be managed by means of negotiation, counselling or the pupil could have complete autonomy. Fig 3 indicated the options open to teacher and pupils.

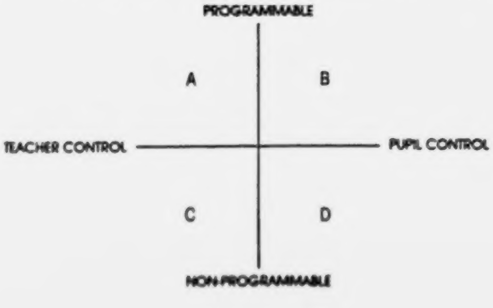


Fig 3.

A - Teacher programmed/dominated - didactic approach

B - Constrained assignments in the area of learning and experience.

C - Teacher orientated tasks/pupil response.

D - Pupils have greater responsibility.

To follow the true nature of school technology the teacher will experience a significant altering of his or her position relative to the curriculum, other colleagues and the pupils. Fig 3 indicates the varied nature of the educating processes at the teacher's disposal. There will be times when it is essential for the teacher to demonstrate considerable leadership. However, there will be an increasing requirement for the teacher to take on the role as an educational technician to activities pursued by the pupils. In all circumstances, the parameters created to encourage pupil activity should allow for capability to be developed and expressed by all.

If the teacher adopts a strategy which involves the pupils in a wide variety of experiences in the different process phases indicated in Fig 3 then one could say that **breadth** will be encouraged.

The balance of the diet will always be difficult to achieve (who defines the balance?). However, if pupils are encouraged to pursue activities which are drawn from a wide variety of areas of learning and experience, and the same pupils develop views, knowledge and skills that can be used as a resource in such activity then a kind of balance will be achieved. However, it should be stressed that balance is not necessarily achieved by covering context alone. Care should be given to the activities of learning to ensure balance is maintained.

There can be little doubt that the models expressed here allow, in their uncorrupted form, for differing ability levels, to achieve more readily their full potential. Providing the environment for **differentiated** learning will undoubtedly require much skill from the teacher.

Technology, perhaps, offers greater opportunity for this to be achieved than a more didactic content loaded route of learning.

The relevance of Technology should be unquestioned. However, we need to be sure that the Technology pupils involve themselves in is framed in such a way as to encourage the simultaneous development and demonstration of knowledge, skills, experience tempered by personal human values. The provision for technological activity should, wherever appropriate (particularly in the late secondary years) be drawing real issues from real contexts. The only TVEI aim which relates directly to what the children should be doing make this point (TVEI aim four)

True Technological activity encqurages the development of capability. However, the issue of progression has not fully been faced. If we, as teachers, are to work in a framework less dominated by content and more concerned with the learning process that pupils are engaged in, then we need to be more sure of the nature of the pupils' progress through the pupils' developing capacities.

Hitherto, accepting GCSE as an advance, all traditional forms of assessing young people have primarily concerned themselves with knowledge retention and what pupils have learnt. We should be sure that the methods of assessing young people do not by their very nature, provide a limiting factor on what pupils might engage themselves in. There needs to be an appreciation of the extensive potential of pupils involved in educational processes that allow them to bring to the fore highly desirable attributes: attributes which, under normal circumstances, might well lie dormant, and certainly not be recognised by any form of traditional assessment. Along with developments in School Technology one would hope for more sophisticated methods of assessing these attributes. Progression should be expressed by what pupils can do through their activities, rather than what they may or may not have learnt.

4 Current Practice

Within the context of compulsory education there remain many models of curriculum structure and methods for delivery. These range from the holistic to the subject division of an overall curriculum with each department stating the aims which collectively are the schools ethos. Various adaptions of delivery are in use or being explored. Amongst these are homogeneous subjects, cross subject courses, linked modules, thematic work, topics, grouped subjects etc. These methods can be and often are additions to a core of study. These organizational patterns however mask the true identity of what is happening to the pupils. It is clear that authorities should seek ways of clarifying the value of technological activity as pursued by pupils in the various curricular delivery models that are being developed and in common use. This work would go some way towards identifying where, how and why pupils are achieving greater potential through School Technology.

Fig 4 aims to demonstrate, through simplistic means, current activity. This is not to say that all School Technology will have developed in this manner. For many years, as suggested earlier in this paper, there have been many examples of excellent active learning of a technological nature, cutting across the traditional disciplines. This has been reinforced and made more widespread by various highly creditable interpretations of such initiatives as TVEI, CPVE and TRIST. However, Technology has been seen by many in schools as being the exclusive domain of the Science and/or Craft, Design and Technology departments. This has been an inhibitor rather than a catalyst for a well developed approach to Technology.

The total experience of pupils is often not recognised as technological, whereas, in fact there are many opportunities that present themselves to young people that would encourage the principles described in this paper, eg designing and making a safe activity ramp for BMX stunts or developing games to play using odds and ends. As the child ages the activity may be more directed toward or controlled by the childs immediate economically based society.

When we view school experiences against this majority influence we should be able to appreciate how minimal the formative experiences developed through separate subjects (which in secondary may be as little as one hour per week) must be. Within this school experience there appears to be little potential for technological activity. This is particularly true of the secondary phase of education where, in the latter years, pupils need not even be engaged in such activity if they are drawn toward certain curricula. It is also true to say that whilst the primary phase appears to be more in sympathy with the principles of Technology by means of its curriculum organization, there still remains much to be done to ensure that its potential is more fully exploited.

If the lighter zones in Fig 4, indicate present potential for technological activity then we are faced with a very patchy and haphazard approach to its implementation. As in some authorities in the country which have encouraged the pyramid

CURRENT PRACTICE

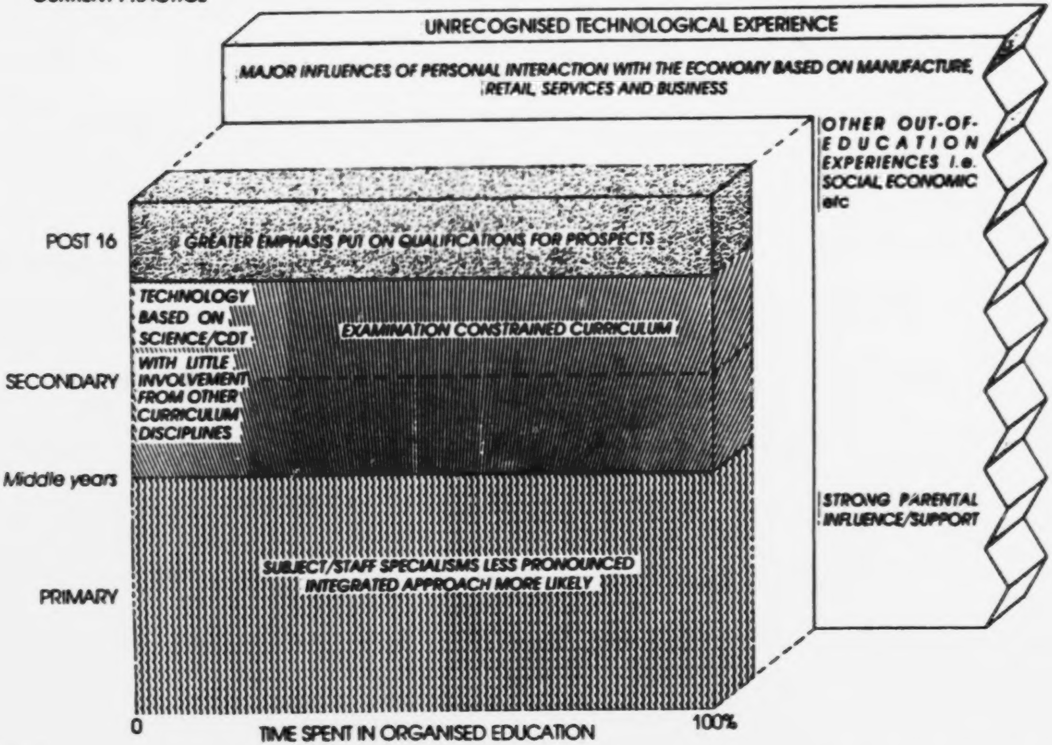

UNRECOGNISED TECHNOLOGICAL EXPERIENCE
MAJOR INFLUENCES OF PERSONAL INTERACTION WITH THE ECONOMY BASED ON MANUFACTURE, RETAIL, SERVICES AND BUSINESS
OTHER OUT-OF-EDUCATION EXPERIENCES i.e. SOCIAL, ECONOMIC etc
STRONG PARENTAL INFLUENCE/SUPPORT
POST 16
GREATER EMPHASIS PUT ON QUALIFICATIONS FOR PROSPECTS
TECHNOLOGY BASED ON SCIENCE/CDT WITH LITTLE INVOLVEMENT FROM OTHER CURRICULUM DISCIPLINES
EXAMINATION CONSTRAINED CURRICULUM
SECONDARY
Middle years
PRIMARY
SUBJECT/STAFF SPECIALISMS LESS PRONOUNCED INTEGRATED APPROACH MORE LIKELY
0
TIME SPENT IN ORGANISED EDUCATION
100%

Fig 4.

development of the curriculum (a secondary with its feeder primaries grouped together), there should be greater emphasis placed on co-ordinated efforts in ensuring progression.

It is also true to say that the narrow understanding and implementation of Technology (as seen particularly in the secondary phase) gives a distinct lack of range (breadth) to activities.

Those wishing to capitalise on the assets implicit in Technology (as described) must pursue a more enlightened course when involved in the implementation or development of Technology in schools.

If we aspire to the view expressed by HMI that 'Technological activity should be experienced by all from 5 to 16' or indeed that Technology in schools is essential in drawing out pupil capability, then we must ensure that the education in which all pupils are involved is designed to take full account of methods created to enhance opportunities in developing, more fully, young peoples abilities, understanding, application and attitudes.

Glossary

School Technology Forum - An informal forum of teacher associations with the general aim of developing and encouraging technological influence and innovation in education.

TVEI; The Technical Vocational Education Initiative -

A government sponsored project (pilot initially, but now to be extended to involve potentially all schools in the secondary phase). Its aims are as follows:

In conjunction with LEAs to explore and test ways of organising and managing the education of 14-18 year old young people across the ability range so that:

i) more of them are attracted to seek the qualifications/skills which will be of direct value to them at work and more of them achieve these qualifications and skills;

ii) they are better equipped to enter the world of employment which will await them;

iii) they acquire a more direct appreciation of the practical appllication of the qualifications for which they are working;

iv) they become accustomed to using their skills and knowledge to solve the real-world problems they will meet at work;

v) more emphasis is placed on developing initiative, motivation and enterprise as well as problem-solving skills and other aspects of personal development;

vi) the construction of the bridge from education to work is begun earlier by giving these young people the opportunity to have direct contact and training/planned work experience with a number of local employers in the relevant specialisms;

vii) there is close collaboration between local education authorities and industry/commerce/public services etc, so that the curriculum has industry's confidence.

GCSE; General Certificate of Secondary Education -

The new rationalised, national summative examination. The assessment is geared to 'what pupils can do' rather than testing 'what pupils don't know'. It features a significant (40-50%) coursework component.

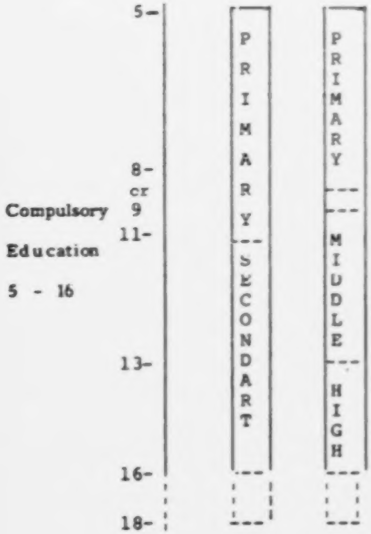
CPVE; Certificate of the Vocational Education -

Courses which offer this certificate, for pupils in the post-16, non-compulsory, phase of education, are locally designed, but have to fit a nationally accepted framework. It encourages the development of transferable skills and broadly follows the TVEI ideals.

TRIST; TVEI Related In-service Training -

This was a crash (two year), centrally funded, programme aimed at retraining teachers in the methods and subject matter appropriate to developing curricula, particularly TVEI-type curricula.

Pre-University Education System in the UK



The prominent system is that of primary/secondary, but some parts of the UK have Primary/Middle/High as their preferred system.

Most schooling is all-ability (some selection for higher abilities still exists) and is co-educational and single sex.

Non-compulsory Post 16 phase in school, at a college of further education, sixth form college, or tertiary college.

HIGHER EDUCATION

Universities, Polytechnics etc.

Autobiography

The author has worked in education for the past 16 years. After being a classroom teacher in five secondary schools a period was spent in curriculum development. During the latter years he has been involved in TEacher Education at Trent Polytechnic, Nottingham, England.

Apart from writing many articles he has co-authored "Technology Across the Curriculum". Currently his interests lie in the research of matters relating to the developing technological curriculum, particularly how pupils progress through process orientated learning.

TECHNOLOGICAL EDUCATION FOR THE YOUNGER PUPIL

Dr. Ray L. Page (Bromley Education Department, Bromley, England)

1. Introduction

In papers presented to the second and third International Symposium on World Trends in Science and Technology Education held in Nottingham, England and Brisbane, Australia respectively, the author explored the nature and purpose of technology; argued a case for technological activity to be included in the secondary school curriculum; outlined ways in which such activity could be introduced into the curriculum (with particular emphasis on Science Department contribution), and discussed a particular project developed in the United Kingdom for the 14-16 age range called "Modular Courses in Technology". In particular its mode of implementation and dissemination was recommended to the Symposium.

In these two papers comment was made that where older pupils had a chance to opt for a choice of subjects, those that had chosen technology had a more positive attitude towards technology and industry than their peers as measured by the Page-Nash-Orr attitude scale. This was found to be particularly true for girls. If attitude plays such an important part in the choice of subjects, if sufficient young people are to come forward and develop careers in the technological field, attention must, therefore, be paid to developing positive attitudes. As attitudes take time to form, the development of a positive attitude towards technology must take place earlier rather than later in pupils' eduction. Studies have already shown that girls in particular come into secondary schools in the United Kingdom with a negative attitude towards science, mathematics and technology.

Technological education cannot, therefore, be limited to the older years of secondary education and attention needs to be paid to the technological education of children of primary school age. In this paper the author discusses some of the problems that have faced his team of Inspectors and Advisory teachers in introducing a technological component into the primary school curriculum in the United Kingdom and, in particular, in the London Borough of Bromley which is an Education Authority on the outskirts of central London.

The departments in secondary schools in the United Kingdom which have contributed most to the introduction of technological activity have tended to be the Science Departments and the Craft and Design Departments, and some of the best developments in technological education have occurred when both these departments have worked together and have involved colleagues from the Humanities Departments as well. No curriculum developer in the United Kingdom, however, would argue that it has been an easy task to introduce Technological Education into secondary schools and it must be remembered that the Science and Design departments had, in many cases, undergone their own curriculum development at an earlier time. The Nuffield Science Developments in the United Kingdom, for example, took place in the 1960's. In other words, departments forming the base for the introduction of technological activity had already undergone their own curriculum development and were relatively ready to take on further development in the technological field.

In primary schools in the United Kingdom the problem of introducing technological activity is that science teaching and design activity are not as yet strongly established which means there is not an established base in science and design on which to build technological activity. This had had to be taken into account by the author's team of Inspectors and Advisory Teachers developing a primary science programme funded by an Educational Support Grant from the Department of Education and Science, and by a similar group working on a Design Dimension project funded by six local Education Authorities, Industry and the Department of Trade and Industry.

I should now like to discuss the primary Science and Technology programme's philosophy, development and implementation (and will present examples of work and a video at the Symposium) and then the Design Dimension's projects work in the primary field (and again examples of pupils' work and a display will be brought to the Symposium).

2. Bromley's ESG Primary Science and Technology Project

The state of primary school science has, and still is, not strong in the United Kingdom. In 1978, the Department of Education and Science carried out a primary survey. The tenor of their findings was that much of the primary science teaching was "ad hoc" and un-coordinated and there was very limited expertise in the teaching force with many teachers lacking a working knowledge of the science appropriate to children of primary age. In addition, there was also a lack of facilities and resources in the primary schools. Not much attention was given to the technological aspect of science teaching and the emphasis of the survey was on pure rather than applied science. The report, however, did emphasise the need for specialist teaching, the teaching of science to all pupils, and the value of time during the working day for co-ordinators of a school's science programme to work with colleagues.

Very little happened as a result of this report, despite the publication of the Schools Council/Nuffield Foundation's Science 5-13 Books in collaboration with MacDonald's Education Publishers in the early 70's. This series became the base line for several published schemes, in particular

Science Horizons and Learning through Science. It should be noted that the science in these schemes was not of a pure, watered-down secondary format, but child-centred with a large component of design and make.

What the originators of these schemes had overlooked was that without sufficient scientific knowledge and experience of teaching science, teachers in primary schools could not change the material in the workcards into a living reality in the classroom. While the impact of the primary survey of 1978 was slow to take effect, Advisers and Inspectors in Local Education Authorities in the United Kingdom began to provide the necessary in-service Education and Training to implement the various published schemes, in some cases developing their own schemes as well. This activity, however, remained largely un-coordinated and under-funded.

It has been quite difficult in the United Kingdom in curriculum development to find the appropriate level of funding and coordinate this with an effective strategy for in-service training and implementation. Primary science in the United Kingdom is a good example of the two being out of step. In the early years there was a level of funding to produce the necessary resources, but there was not the network of in-service training to provide the expertise needed in the teaching force. When this expertise started to be developed, there was not the funding to provide the appropriate resource levels. This is, of course, a simplification of the actual situation, but has been done to make a key point; namely, that the funding of resources and the necessary in-service training programme must be properly coordinated for any curriculum development to succeed.

To maintain the development of the early 80's, the Department of Education and Science produced a discussion paper entitled "Science in Primary Schools in 1983". The document indicated what suitable steps should be taken in order that proper scientific (and technological) education would take place in primary schools. For example in selecting the content the paper suggests:

1. The content should, wherever possible, be related to the experiences of the children.

2. It should, in accordance with their stages of development, provide them with knowledge and understanding of scientific ideas to help them to understand their own physical and biological environments and to understand themselves.

3. It should, where possible, lay the foundation for a progressively deepening knowledge and understanding of scientific concepts and facts that will be useful to them as future citizens.

4. It should include examples of the application of science to real-life problems including those of technology.

The outcome of this discussion paper was for pressure to be put on the Department of Education and Science from Local Authorities and its own Inspectorate (i.e. Her Majesty's Inspectors) to help provide the necessary resources and training to develop primary science programmes. At the same time there were pressures for similar support for other areas of the curriculum across the whole age range of 5-19. As a consequence, the then Secretary of State for Education, Sir Keith Joseph, set up a scheme for Educational Support Grants. In the case of primary science £3 million was made available for the hundred or so Local Education Authorities to make competitive bids for development in their own Authority, which covered both the production of resources and the necessary training of teachers. In all, some forty Local Education Authorities obtained Educational Support Grants the first time round from this £3 million to set up their own projects, and Bromley was one of these forty. Submissions for funding had to be written in 1984, and the successful Local Education Authorities started their projects in September 1985, running for three years to August 1988. A further £3 million was made available in September 1986 for other Authorities to make bids.

The Education Support Grant arrangements for primary school science made it quite clear that there was to be a direct relationship between science and technology. Indeed, Bromley's submission was, with two others, used as an example by the Departmant of Education and Science of that relationship, and was circulated to other Local Education Authorities that had not been successful the first time round.

The Education Support Grant scheme has been a considerable success in the United Kingdom because it has provided money directly to Local Education Authorities for the appointment of Advisers/Advisory Teachers to support colleague teachers, the development of resources, and for paying for teachers to cover for teachers going for in-service training courses. Previously the Government had made money available to Local Authorities who then made their own decisions as to what money was spent on curriculum development and in-service training.

In many cases this meant that very inadequate funding was made available for these activities. The scheme, of course, is not without its critics who believe that this is taking authority away from the local scene into Central Government. This has raised the issue, yet again, of the advantages and disadvantages between a centralised educational system and a locally administered one. For the author, the Educational Support Grants scheme represents a reasonable compromise and a workable one. It is unrealistic for Local Education Authorities in a modern technological society, to expect that they can ignore national needs and demands. Equally, however, there will be local and individual requirements and, provided the criteria allow a degree of flexibility, both the national need and the local requirement can be met. So far the Department of Education & Science has laid down broad guidelines in key areas, and an analysis of the various projects which have been funded indicate that the Department of Eduction & Science are prepared to allow a fair degree of flexibility.

In Bromley, the primary science ESG project is being supervised by the Authority's General Inspector for Mathematics, Science, Computer Education and Technology working with two advisory teachers on equivalent salary scales to primary school Head Teachers. The strategy for the development is that a group of primary schools release the teachers who will act as the Science/Co-ordinators to attend in-service training. This training has a three-fold purpose:

(a) To improve and increase the scientific understanding of the teachers involved so that they can handle concepts in the areas of energy, structures, materials, the living world, and so on.

(b) Have direct experience of simple practical work and develop an understanding of how to organise such activity in the primary classroom.

(c) Become acquainted with the resources needed to develop a coherent science policy - the Bromley project is using the material from the Learning Science scheme.

Cover for the teacher's in-service release is granted and extends to giving them time when they return to school to develop the necessary resources and to talk with their colleagues so that they too can begin to introduce science into their teaching. The two peripatetic advisory teachers visit the schools and give further help and support as confidence develops.

At the Conference the author will have on display cards from the Learning through Science scheme, with photographs to illustrate how the work is developed from these cards, particularly with respect to technological activity. It is also hoped that a video will be prepared to run alongside this material to illustrate the work that has been going on in Bromley primary schools in developing technological activity from a science base, which will be shown at the author's session.

3. The Design Dimension Project

The Design Dimension project is a national curriculum development which has as its overall aim the establishment of design education as a central concern of primary and secondary schools. In order to achieve this overall aim, the project seeks:

(1) To clarify the contributions that a range of school subjects can make to design education, to show the possible connection between them and to promote a wider understanding of what constitutes design education:

(2) To develop further the teaching and learning methods that are effective in encouraging the growth of design skills capacity, intelligence and awareness:

(3) To disseminate the results of the project's work through a cascade model, starting with four Local Education Authorities.

To achieve these aims the project is giving priority to the four crucial areas of curriculum investigation and development; the establishment of centres of excellence (in the first instance in four Local Education Authorities, including Bromley) where good practice can be fostered and made visible; teaching staff development and the production of resource material.

It is the belief of the project team that the primary aim of design in general education is to develop everybody's design awareness so that they can:

(1) Enjoy with understanding and insight the made world of places, products and images:

(2) Take part in the person and public design decisions that affect their lives and the life of the community:

(3) Design and criticise design at their own level for their own material and spiritual needs:

(4) Bring an understanding of design into their work.

Fundamental to design activity is the skill of "imaging". This is the ability to make and use sketches, drawings, diagrams, plans, scale models, mock-ups, prototypes and the like to represent, shape and evaluate what is and what might be.

Designing is a fundamental part of technological activity, and indeed, many people would argue that the marriage of design and science equates to technological activity.

The Bromley Design Dimension project is using a British Leyland "flexibus" as a mobile workshop and resource unit. This vehicle is the flagship of the project and is furnished with the relevant equipment needed to support design studies. It can be used for seminars, discussions, audiovisual presentations, exhibitions and houses a comprehensive set of literature and curriculum support material.

The project is a partnership between Bromley and the Department of Trade and Industry, in association with the participating authorities in the first phase of Gloucestershire, Cleveland and Sutton.

The Field Officer of the project has developed a particular interest in the development of design and technology in primary schools and is concerned that if design awareness and skills, and an understanding of basic scientific concepts, are overlooked, there is a real danger that technology in many primary schools will be seen as little more than an extension of existing craft practices, with a heavy emphasis on repetitive and copied model making.

The author of this paper will be bringing a display of work that has been going on in primary schools under the auspices of the Design Dimension project to illustrate how craft work has been developed into design work, and then progressed to technological activity.

4. Technology in Primary Schools

If "ad hoc" science work, largely confined to nature study, is developed into a coherent science programme in primary schools (where pupils are introduced to the scientific process and core concepts/skills in science); and if craft work (which is largely confined to model making) is extended into design activities, primary schools will have a base from which to move into technology.

If this strategy is developed, the pitfalls of the "popular" approach to primary school technology of the repetitive use of building models (particularly bridges, kites, gliders and wheeled vehicles of various kinds), can be avoided. This "popular" approach presents a very narrow view of technology and quickly degenerates into the use of formulii which have been found to work successfully in the past. Model making such as this fails to encourage children to find and use existing knowledge, or create new knowledge through experiment; it ignores social values and judgements; and presents an image of technology to the child, parent and teachers of a purely recreational activity. It also largely ignores the systematic technological approach to solving problems and, therefore, neither allows the child to experience to any depth the technologist's role nor increases their general technological awareness.

Finally, if technology is to be developed from primary science and design activities, Head Teachers must ensure that there is a strategy and mechanism for doing this in their schools. Certainly the co-ordinators of Science and Design will need to coordinate their work, and that of the other teachers in the school, so that their teaching does not stop short of mounting technological projects. Schools must also avoid choosing starting points which may not challenge children to problem-solve, because they have already seen solutions in real life.

Thus building a land-yacht to cross the playground may not exercise their technological problem-solving skills as much as asking them to consider the problem of hardness testing and devising a method for doing this. In-service training and education must also not avoid helping teachers acquire basic scientific and design knowledge themselves, and the associated practical skills. This is particularly true with respect to tool skills as most primary schools have a high number of women teachers who have had little or no formal training in the use of tools.

It is also important that technological project work should not be separated from making pupils more aware about technology in general. The two should be supportive of each other and each can develop through a consideration of the other.

In the United Kingdom it is essential that children develop an awareness and appreciation of technological activity in the primary school, in order that this experience helps them develop positive attitudes and overcome the feelings of strangeness that they may feel about secondary school technology, particularly girls.

(a) Pre-University Educational System in the United Kingdom

The United Kingdom has a three stage educational system run by around 120 Local Education Authorities:

Primary	5-11	All ability, co-educational, and sometimes seprated into infant (5-7) and junior (7-11).
Secondary	11-16	Mainly all-ability; co-educational and single sex; some Authorities still retain an element of selection, but only a few have a fully selective system where at 11 children are selected by examination for particular schools, i.e. grammar, technical or secondary modern.
Tertiary	16 upwards	Further: Sixth Form Colleges, Technical Colleges, Further Education Colleges etc.
	Higher:	Institutes of Higher Education, Polytechnics, Universities etc.,

Further Education starts at 16, Higher Education at 18, with secondary schools still providing courses for the 16-18 age group for many pupils. Entry to Higher Education is by examination and normally three good passes at Advanced level of the General Certificate of Education are needed.

Some Authorities provide a first, middle and upper school system, which bridges these 3 stages, i.e:

First School - 5 to 9
Middle School - 5 to 14
Upper School - 14 to 18

Bromley is a small Local Education Authority on the outskirts of London with 20 secondary schools, 84 primary schools, 5 special schools, and 3 F/HE Colleges.

(b) The author's paper relates to the primary school stage and the development of science and technology curriculum in primary schools.

In the structure of the Symposium it relates to Section 2.2, but the accompanying material will fit the requirement of Section 2.4.

(c) Autobiographical Note

The author has spent some 25 years in education in the United Kingdom. After teaching at two seondary schools, a period of 10 years was spent in teacher training, first at a College of Education and then at Bath University School of Education. In 1978 the author took up the post of General Inspector for Science, Mathematics, Technology, and Computer Education in Bromley.

In 1981, he was promoted to the rank of Principal Assistant Director of Education for the Inspectorate, Primary schools and Special Education, exchanging the latter two areas of responsibility for Secondary schools in 1982.

TECHNOLOGY AND IMPROVEMENT OF EDUCATION FOR MINORITY AND HANDICAPPED STUDENTS

Hugh J. Scott, John Niman, Lester Mann (Hunter College/City University of New York)

Introduction

Whenever asked to discuss the educational values of computers we often recall a dialog between Mahatma Ghandi and a reporter. The latter asked Ghandi:
Mr. Ghandi, what do you think of Western Civilization?"
Ghandi replied:
" It was probably a good idea."

Alas, the fate of good ideas and of those who propose them is not always encouraging. An object lesson to this effect was once provided—albeit unwittingly—by a fifth grade student who was asked by his teacher to tell what he knew about Socrates. The student's response?

"Socrates was a great man.
Socrates was a wise man.
Socrates gave good advice to others.
They poisoned Socrates."

Our presentation, then, attempts to address some of the issues confronting the use of computer and computer based technologies with two significant groups of the American student population in the United States towards whose needs for such technology particularly must be addressed: The first of these groups consists of urban disadvantaged students, i.e., black inner city children and students of recent foreign antecedents for whom English is a second language. e.g., Hispanic students. The second group is constituted from handicapped students; the latter now represent major targets for educational efforts in the United States, which is seeking to bring such students into the mainstream of American society.

We offer our paper, its review and our opinions with stronger beliefs than Ghandi held about Western civilization—for we know that computer education is a good idea! We also offer our opinions knowing, as did our student narrating his Socratean tale, that giving others good advice is is not always appreciated, but believing—nonetheless— that it is worth giving.

The Crisis in Achievement of Minority Students in America

Blacks and Hispanics constitute 25% of so of the population in the United States; that percentage is expected to swell to 33% by the year 2000. New York City, which currently serves an enrollment of some 936,000 students, 1/3 of whom come from families on welfare, and 40% of whose first graders come from homes where no English is spoken, has seen a 30% increase in such students over recent years. Whereas white school children were in the majority in 24 out of 25 major cities in the United States during the 1950s, the current situation is exactly the reverse. Unfortunately, in America, a child's race or socioeconomic status serves as the major determinant of success or failure in the schools. And, despite the many and great strides achieved by such students since the 1960's, they still suffer considerable social, economic, and educational inequities— and many of their children remain disadvantaged in their efforts to achieve the American dream through education. Black and Hispanic students are under-represented in programs for the gifted and talented and in those that involve high level technical preparation. They are over-represented in vocational educational programs that prepare students for low-status occupations. Above all, perhaps, black and Hispanic students are likely to be the recipients of a generally inferior education as compared to their white peers.

The inequities suffered by minority, i.e., Black and Hispanic students are acute, most particularly within urban school settings, where minority problems of underachievement are at a crisis point. The continued lack of effective attention to the educational needs of minority students in The United States is testified to by a massive dropout rates in its cities. Nationwide, only 55.5% of Hispanics between the age of 18 and 34 complete high school as compared to 83.9% for whites and non-Hispanics. A similar picture emerges at the college level: 32% of the general American population completes some college versus 18% of Hispanics.

Particularly ominous for our minority students, as the world rushes into our technological future, is that minority students consistently score below U.S. national averages in mathematics achievement tests; and that they rarely choose to enroll in mathematics or science courses on their own volition[1]. The negative implications of such findings for the technological future of minority students is attested to in a variety of ways. For example, in engineering schools only 3% of blacks enter, far below their percentage in the general population. Furthermore, of these only 30% complete their schooling (and 40% of Hispanics) as compared to 70% of all other students.

A similar picture presents itself on the employment scene. Whereas, 10% of the labor force consists of blacks, only 2.5% of science and engineering professionals is black, and of these they are likely to have backgrounds in social and behaviorial rather than physical science (thus less likely to be technologically proficient), and generally assigned to administrative duties (thus removing them from the technological mainstream).

The statistics emerging from national test benchmarks of academic achievement are in similar veins. Thus on the 1985 Scholastic Aptitude Tests (SATS) average scores of 490 in mathematics were registered for white, compared to only 405 for Puerto Ricans and 376 for Blacks.

Nor are the achievement results encouraging in other areas. The heart of technological proficiency is mathematical proficiency. However, such proficiency, to achieve its fullest requires the participation of other factors beyond "pure" mathematical capabilities. The most important of which is language competency in which minority groups have also tended to show low achievement. Research clearly reveals significant and definitive correlations between achievement in mathematics and reading ability. Thus, the inadequate and inefficient reading achievement of many Black and Hispanic students, the consequences of inadequate pedagogy by and large, means that their mathematical achievement will be negatively affected, even when they have good mathematical potential. This is to be expected—of course. While simple mathematical computations may not pose great difficulties for the non English proficient students, language proficiency is essential to translate word problems (often densely packed with information) into mathematical symbols and operations. Should we not then expect mathematical difficulties from Hispanic students, approximately 1/2 of whom, attending American schools, have been identified as having limited oral and written English proficiency[2]. The 1985 SATs reveal that the average verbal scores for whites was 449 versus 373 for Puerto Ricans and 346 for Blacks; still another testimony to the inadequate education provided minority students in the United States.

Clearly the challenges presented to American education by minority students are massive ones, requiring significant gains on many fronts if significant achievements are to be made in preparing them to take their places in today's and tomorrow's technological societies. The enormity of the challenge that confronts American society in this respect is presently on stage in the form of adult illiteracy.

Adult Illiteracy

There are different approaches to determining the minimum levels of functional literacy. Educators have often defined it as being able to read at a 6th grade level. More ambitious viewpoints assign it to the 8th grade reading level. According to the U.S. Department of Education there are currently over 27 million adults over the age of 16 who are functionally illiterate. Nor is this percentage likely to remain static for the numbers of such illiterates are growing at a rate of 2.3 million a year; i.e., with the addition of 1.3 non English speaking immigrants (both legal and non legal) and another million or so American high school dropouts or graduates with inadequate reading skills.

According to the National Assessment of Educational Progress (NAEP), 41% of black 17 year olds are functionally illiterate, as compared with 8% of their white peers. This illiteracy means that they have difficulty in following directions for cooking a TV dinner, in reading directions on an Aspirin bottle, or in writing a check. In Atlanta, Georgia, it was found that one out of eight workers in city government cannot read or write! It is clearly evident that the language competencies, while required by minority and other students--in their own right, must be essential foci of educational attention for minority students if they are to achieve the technological proficiency to succeed in today's technological society, are at crisis levels.

Much of the computer technology to reduce the crisis of technological inadequacies on the part of minority students is already in place[3]. Let us just mention a few. A writing to read computer generated reading program developed by the Educator John Martin and IBM has already been found to have achieved considerable success with some 300,000 school children across the country in respect to the acquisition of basic reading skills. A similar venture, begun September 1986, is designed to combat the illliteracy problems of adults--those who read below the fifth grade level. This program, PALS-Principles of the Alphabet Literacy System-uses an IBM Infowindow touch sensitive monitor, a Pioneer LV-D-6000 videodisk player and programmed videodisks. Such programs effectively address problems of illiteracy and have a good potential for improving the reading skills of limited English proficient children; they are also addressing the needs of prison inmates, many of whom are functionally illiterate.

The most visible example of computer technology that can make even quasi-illiterates functional in the marketplace to some degree is a ubiqutious one: The word processor! Correcting handwriting deficiencies, spelling errors, and even syntactical and semantic ones, The word processor is a great boon to students, who because of language deficits or foreign language backgrounds, have difficulties with the English language. It can help students with low verbal skills carry out assignments, both in school and in work situations, who, in previous years would have been entirely barred from any success.

Finally, it must be observed that there are extensive and effective computer based mathematics instruction programs that have extended the main frame insights of such scholars like Patrick Suppes down into the world of microcomputers. From simple calculation skills through the higher realms of trigonometry and beyond, there are computer programs now, to teach, drill, and remedially assist students in mathematics.

It is evident, then, that the computer assisted technology for improving the language skills required for mathematical proficiency of low English proficient students is now at hand,

and improving daily. While, as concerns mathematical proficiency itself (language factors apart), computer assisted technology for mathematically training students language proficiency is not only available but is extensive and mature.

Clearly then, there is no excuse now not to seek to remedy the mathematical and language deficiencies of minority and English deficient students in the United States. However, the effective implementation of educational technology is dependent on major financial investments, and the American society has been loathe to commit itself to such investments. Thus, the school districts that currently provide the greatest amounts of computer instruction to their students are almost always located in the more affluent of American communities, where parents are most likely to insist that their children receive such instruction while at the same time their are garnished by one or more home computers, replete with appropriate educational software for their children. Indeed, it has been determined that computer assisted instruction was initially inaugurated in American schools by the insistence of white, middle class —mainly suburban—families, rather than by teachers, school administrators or computer manufacturers[4]. Conversely, American schools serving poor and language disadvantaged students are usually under-financed and have great difficulty in providing the barest of computer technology and programming for their underprivileged charges; while the parents of the children attending these schools, individuals struggling to provide the bare necessities of life, and often suffering from poor educational experiences themselves, cannot be expected to urge schools onward in respect to providing computer instruction, nor to provide home assistance to such instruction themselves; It is unreasonable to expect to find home computers in Ghetto homes!

There are trends mitigating against the improvement of these circumstances over the next several years, as efforts to reduce Federal spending accelerate. Indeed, many educators believe that if there are reductions of expenditures in education in the future that these reductions are most likely to penalize school districts serving economically disadvantaged groups—most usually concentrated in large urban areas— the most. If this will be true, the hope of helping minority and other underprivileged school children capable of dealing with tomorrow's technological world will be dashed and severe social consequences will result for the American society. The hope for a more promising future in respect to these children depends on an enlightened public, able to recognize that effective education is essential to the well being of the United States, and their ability— as well— to recognize the the cost efficiencies of computer assisted instruction. We shall return to this point at the close of our presentation.

Computer Use in Special Education

While there is still much to be done, it cannot be denied that the American public has generously committed resources to helping handicapped students over the past several years; indeed to helping handicapped individuals of all ages. And, the results are impressive in respect to the acceptance of computer technology by educators of the handicapped[6]. Thus, in 1985 it was reported that 10% of elementary and secondary schools using microcomputers in the classroom were special education teachers.

The most important outcomes of the microchip age has been in respect to making life personally livable for the handicapped of all ages[6]; and without extensive human help, which is either unavailable or too costly to provide on a regular basis. This microchip technology includes electronically controlled wheelchairs, walking sticks for the blind that can sense barriers, synthetic speech generators for the hearing and language impaired, computer controlled devices that enable individuals with leg incapacities to walk and devices which assist paralyzed individuals to control a computer with an eye blink. It also includes everyday, commonplace word processors, which permit neurologically impaired individuals to replace deficient visual motor skills and spelling deficiencies and even correct their chronic syntactical ones. Thanks to the microchip revolution, autistic children, estranged from the environment and from other individuals by their psychopathologies, can communicate with others via computer keyboards and drawing tablets which allow them to feel more comfortable and secure in the world around them. Thanks to it as well, physically handicapped students, restricted in their opportunities for communication, are able to electronically interact with peers and mentors,— both physically handicapped students and non handicapped— even when their handicaps restrict them to their homes.

A most important aspect of microcomputers for the handicapped (for whom relationships with other individuals is often difficult and stressful, is that they are easy to anthropomorphize). Thus, handicapped children may often be found to see microcomputers as "friends" as well as teaching and prosthetic devices. The microcomputer, a non threatening steady influence in their lives can thus be very helpful in making them feel both more comfortable with themselves and others.

Microcircuitry has also made possible major educational advances for the handicapped[5,6]. CAI programs are helping many learning disabled, mentally retarded, physically handicapped and deaf and blind students to overcome their handicaps or to learn despite them. There are cognitive training and retraining programs for neurologically and mentally retarded students. There are drill and practice programs for learning disabled students who cannot learn except with extensive repetition. The computer provides memory supports for those who are deficient in storage of information or its recall, and provides organization and structure for those whose handicaps have made these difficult to achieve unaided.

Also of great importance, in addition to the computer contributions to the well being and education of the handicapped, is the fact that computerized technologies are enabling handicapped students to become productive working adults, and to often be employed in technological capacities—despite their handicaps. The use of microcomputers makes it possible to prepare physically handicapped students, and to later aid them as adults, for technological jobs, either at home or in the daily workplace; it also provides them with the mobility that they need to effectively work. Blind students training for later work careers can read all sorts of regular printed materials using Opticons, and with the help of VersaBraillers translate word processing texts and spread sheet data to Braille, and later translate their own Braille work into regular word processing and spread sheet files for their seeing coworkers to read. Students with limited vision who are preparing for the work force can be taught to use the Vista Vert Plus machines to combine large print matters on a monitor with synthetic speech.

For those who are deaf there are now contoured hearing aids that specially address their unique hearing disabilities and technology that translates the human voice into graphic or printed representations, all of which makes it more likely that they can be educationally prepared to work amidst the hearing

For the learning disabled and mentally retarded there are means of turning alphanumeric combinations which they cannot understand into graphic symbols which they can recognize and manipulate. They can thus be taught to use visually configured cash registers and prepare for jobs which their language and mathematics deficiencies would have prohibited them from in an earlier, non technological age. They can learn to charge correct amounts for things with names and costs numbers they cannot read or calculate —and learn to give correct change as well—all because of microcomputers. Whereas hand calculators have made balancing of checkbooks and digital watches the telling of time—all part of the the workday world— possible for handicapped students whose cognitive disabilities once entirely barred them from such achievements.
It should be observed here that many of the technologies suitable for low achieving non-handicapped students can profitably be used with learning disabled and retarded ones; and— vice versa!

Perhaps most important for the handicapped student, even though it cannot necessarily be directly correlated with achievements in school or to job success is the fact that microcomputers can instill a sense of personal competency in the handicapped learner. Handicapped learners are prone to view themselves as helpless and at the mercy of environmental forces beyond their control. Using microcomputers they may develop a sense of being able to exert "power" and feel able to affect their environments through their own efforts; to make things happen through their own actions! How important are such attitudes and feelings to individuals who so often are made to feel powerless and inept! Thus, microcomputers can be sources of considerable self enhancement for handicapped individuals.

The Challenge and the Problems

The technology of the computer age stands ready to improve the education, work capabilities and lives of students who previously, either because of societal punishments visited upon them because of their minority status, or because of English language limitations, or because of handicaps have been denied the full benefits of American education. That technology may not be fully perfected at present. It is, however, fully capable now of significantly transforming the lives of minority students suffering from academic failure, of Hispanics whose futures are presently foreclosed because they cannot fully respond to instruction in English, and of handicapped students who just now--finally--are being invited to take their places in the mainstream of American schools and society[7,8].

Unfortunately schools in the United States have not adequately applied the fruits of the computer revolution to their needs of education. They rarely have enough computer equipment to effectively serve their students. They have seldom hired the best of computer consultants and programmers to advise or manage their efforts at either programming or using existing applications--because of their unwillingness to pay the going rate required for the best of these. Educational software houses have dumped massive amounts of pedagogically unsound software on the market --which, when used, has discouraged many teachers from further attempts to use computers instructionally. Worst of all, perhaps, is that school boards have expected teachers to become experts in the instructional use of computers after minimal periods of training and opportunities for practice. The typical scene through most schools still is either (a) insufficient microcomputers and software,(2) ill prepared or inadequate numbers of professionals to apply computers instructionally, or (3) both. Also, as all of us know, there has been little definitive research done to determine the best uses of computer assisted instruction (though it has decidedly accelerated during the past several years). Certainly, we still know little as to how best use computers with and for inner city disadvantaged school children, children with English language deficiencies and those with special needs dictated by their handicaps.

But we need not become discouraged. New trends in American education are emerging. The American public has finally realized that its teachers are inadequately paid and the salaries for teachers have risen dramatically over the past two years. At the same time, recent figures published by Forbes Magazine indicate that increased expenditures for education do not appear to result in greater educational gains, and such figures are now being used by enemies of public education to fight against further increases in financial support of American public schools. The enemies of public education, and even those critics who support it, are not very willing to accept the reasonable arguments by defenders of public education, to the effect that the public schools of today have more demands placed upon them now than ever before: both in terms of the diversity of student populations and increased student problems. Nor do they wish to hear that public schools must now accommodate students—in overwhelming numbers— who cannot manage the English language or who are handicapped, or whose earlier experiences have created massive pre-educational deficits; or that teaching handicapped students is an extremely costly proposition. They simply point to the fact that increased financing of public education does not appear to have resulted in improved school achievement.

We believe that many of the arguments of those who criticize American public schools are either naive or specious. We also believe that they can be beneficial. For their challenges—and threats— to the American public school system will finally force that system to invest in computer assisted instruction so as to become more cost efficient— and to a degree that will, at long last, make a real, and visible difference in the public schools' use of computer technology to help minority, English language deficient, and handicapped students. We are talking here, not of the possibilities of the future, but of the capacities of the present. For the computer, particularly the microcomputer, is admirably suited to perform those tasks that the American public, and the critics of American public education, demands most from its schools. They do not complain that the students who pass through our schools cannot understand the finer points of Shakespeare or that they cannot master Boolean Algebra. Nor does that public usually insist upon any particular theories or philophies of education. Instead, that public is insisting that the schools teach their students the fundamentals of reading, writing and arithmetic. And for these purposes, teaching computers, tirelessly in willingness to engage in repetitive instruction, patient and non abusive or humiliating, and forever ready to help upon demand, are ideal. They can benefit regular learners. They are essential for those students who are disadvantaged, have problems mastering the English language, or who are handicapped.

And—just as it took the shock of the Japanese automobile invasion in the United States to shake American car manufacturers out of their torpor and to adopt new technologies to improve their products; so will the rising voice of critics finally force implementation of computer technology in our schools. It is about time!

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TECHNOLOGY AS PART OF GENERAL EDUCATION

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Historical Perspective

Technology is as ancient as mankind. As man developed so did the quality and sophistication of his tools. However, much of the earlier technological development had been through handicrafts, which led to the first industrial revolution. Gradually, technology grew to be more complex and its activities have never been more widespread and revolutionary as in the second half of the twentieth century. So much so that during the last decades it has, along with science, become an all-pervasive driving force in our socio-cultural and economic development both in the urban and rural environments, influencing our attitudes and values in daily life.

In early days when there were no schools, the village craftsman played a significant role in teaching technological knowledge and skills related to the immediate environment of the learner. With the institutionalization of learning, the learner became isolated in an artificial world of the school where education tended to be more academic emphasizing intellectual development. Since technology symbolizing manual work was not identified as a possible academic pathway for some employment, it lost favour both with students and their parents and acquired a certain disdain as something inferior to academic education. As a result formal education related to technology took time to develop. And uttimately, when it did towards the end of the nineteenth century, attempts in western countries were made to initiate it through special schools catering mainly for those unable to pursue the academic education. Sadly, many developing countries followed suit. The immediate consequence of this dichotomy was that almost all students pursuing general education remained ignorant of the working of technology which, along with science, is a necessary prerequisite for improving and sustaining the complex structure of modern civilization. Thus, while we need engineers, scientists and technicians for the purpose, we also need a population who is knowledgeable and supportive of both science and technology and is able to exercise its choice of available technological options to solve its emerging needs.

General Education and Technology

Following the policy of democratization of education in many developing countries, there emerged a trend for generalization of school education. In this respect Para 11.7 of the Unesco Recommendation concerning technical and vocational education (1962) reads, "...the cultural content of technical and vocational education should be set at such a level that the inevitable specialization does not stifle broader interests. On the other hand, general education should not be limited to providing knowledge but should also prepare every student for active participation in life by providing him with an understanding of the production and utilization of goods created with the help of technology and with a better comprehension of the world in which he lives". This Recommendation was revised in 1974. Para 19, item IV emphasizes that "initiation to technology and to the world of work should be an essential component of general education, without which this education is incomplete. An understanding of the technological facet of modern culture in both its positive and negative attributes, and an appreciation of work requiring practical skills should thereby be acquired".

Few would argue with these statements but they have been conceived as part of Unesco's programme in technical and vocational education and hence underscores the closer relationship between the world of work and the vocational aspect of general education on the one hand and underestimates the value of technology as compeer to science.

Although technical and vocational education has gained greater significance in various governments' educational planning and policies, the proportion of students enrolled for this purpose has remained small in most developing countries. In one Asian survey, Singh (1986) has pointed out that as many as nine countries have less than 3 per cent enrolment, while 8 have between 3 and 10 percent, and only three countries are close to 20 per cent. Thus the majority of students who are in non-technical general education schools should not be deprived of technology as an increasing new dimension of modern culture.

Rationale for Technology in General Education

Many of the changes occuring in the world today have their roots in science and technology resulting either from the expansion of knowledge or from its application in finding practical solutions to our various problems. Thus technology has a role to play in helping people to cope with socio-economic changes as well as problems arising out of the consequences of technological development. Education, long regarded as an instrument of change, must in itself change in order to remain effective as such. It should benefit from the technological progress and attempt to reflect its contents, methods and philosophy. Thus, introduction of technology as component of general education can serve as a new thrust for school curriculum renewal and relevance. While contributing to the overall development of individuals and nations, it can provide for sensitivity and creativity, encourage the formation of positive values and attitudes, and help realize responsibility in dealing with the environment. Any one who goes to school now to learn only the classical and literary subjects will be rather ill-equipped to live the life of tomorrow. It should therefore be remembered that those who enter school today will have a greater span of their working life ahead of them. The general education must prepare them accordingly. Introduction of technology as its essential component can help in providing the balance to the predominantly theoretical and academic white-collared education. In planning the technological component of general education, a holistic approach should be adopted taking into consideration available resources - financial, physical and human in terms of local educational and socio-cultural needs. Through this, children can be made aware of how technological inventions and products are developed and how they affect their everyday life for better or worse. Thus, for an education to be complete and relevant to future needs, it must have technology as an essential component.

Unesco's Efforts

In addition to technical and vocational education, the teaching of science and technology has been a distinct but essential component of Unesco's programmes and activities for pre-university education but its impact, until recently, has been mostly in extending and improving science rather than technology education. As a result, curricula in general education have been prone to make room for science which over the years, has become an integral part of them in almost all Member States. In order to correct this imbalance, one of the immediate tasks confronting Unesco was to determine the 'state-of-the-art' of technology in general education and pool the available information and usable experience on the subject. Thus, a series of 37 case studies (1979-80), pilot projects (1981-83), global survey (1986) and an international symposium on the subject (1985) were specifically organized as part of Unesco's programme on the teaching of science and technology. Some recent meetings with bearing on technology education include those held in Singapore (1976), Cairo (1978), Paris (1980, 1981). The said case studies have since been synthesized and published as Volume 4 of the Science and Technology Education Document Series (1983). Currently, a teacher's guide and some teaching-learning modules on the subject of technology as part of general education are under preparation.

Place of Technology in School Curricula

Of the 161 Unesco Member States in 1984, 97 replied to the questionnaire to determine the place of science and technology in their school curricula. Based on these returns and the synthesis of 37 case studies (1983), the situation of technology and its teaching is far from clear and is strongly indicative of a wide-spread need for help. Many countries in Africa, the Arab States, Asia, Europe and Latin America do not show any technology teaching on their primary time-tables. In the Arab States, Yemen categorically denies teaching of any technology while sixteen countries make no entries under the heading of technology. An average total time ranges from 1.6 hours (grades 1-2) to 1.5 hours (grades 3-6) and 2.6 hours (grades 7-9). It emerges that technology teaching as part of general education is comparatively recent, and, as yet, there is little consensus about how it can or should be done even among those countries making a determined attempt to do so. In the absence of an agreed or commonly understood meaning of 'technology', the 'what' and 'how' of its teaching is rather diffused and confused; and so different countries vary in their approach, organization and emphasis in pursuing it in their general education.

Many respondents from Africa, the Arab States, Asia, Europe and Latin America have treated technology either in the form of technical and vocationas subjects to develop selected skills for specific vocations or as art and craft and home science to serve as an initiation to manual skills or work experience. Thus, Kenya mentions simple 'art and craft' while Rawanda lists carpentry, bricklaying, home-making and agriculture under technology teaching at primary level. At secondary level technology is taught through a variety of technical subjects such as woodwork/metalwork and technical drawing (Botswana, Malawi, Tunisia, Uruguay); home economics/science (Austria, Kenya, Malaysia, Brazil, Sri Lanka, Denmark, Finland); crafts/handicrafts (Austria, Brazil, Chile, Finland, France, Ghana, Syria, Morocco, Ukrainian SSR, Zaire, Japan); agriculture/agrotechnical studies (Brazil, China, Pakistan, Malaysia, Costa Rica, Guinea, Hungary); technical drawing (Botswana, Malawi, Great Britain, many Arab States); commercial subjects (Sudan, Tanzania, Kenya, Malaysia); industrial arts (Australia, U.S.A., St. Lucia, Sudan); computer studies (Australia, Norway, U.K., the Netherlands); and other subjects including electricity, electronics and design, etc. (U.K., Denmark, France). Practical activities are mentioned by India where socially useful productive work (SUPW) is a compulsory element of education in grades 9-12. Judging from the time allocation, it appears that technology is a significant feature of education in countries of Latin America and the Caribbean. The term 'technology' seems to have a very broad connotation in the region. In Colombia, for example, various options included under this heading refer to vocational abilities and skills such as typewriting, broadcasting techniques, agricultural activities, toymaking, modelling, cooking or exploitation of marine resources. There are yet other countries (Cameroon, Uganda, Gambia, Seychelles, Kenya) where technology is taught through science education.

Despite this broad array of subjects treated under technology, there are certain distinct trends making the evolution of 'technology' as a subject in the general school curriculum. France, for example, reported that technical subjects in the school curricula are now being replaced slowly by such technology courses as informatics, electronics, mechanics and system management. They are to be directed towards finding a solution to problems arising in industry and commerce with students exercising the choice of bias. Likewise, attemtps are in progress in England and Wales to replace training in manual skills with courses in technology based on Craft, Design and Technology (CDT) curriculum prepared by Her Majesty's Inspectors experienced in the field. Similarly, Scotland is also developing a course in technology as part of a project, "Education for the Industrial Society'. In Quebec (Canada) an Introduction to Technology course is compulsory to all secondary III students. This is based on five themes namely: technology in the life of man, building construction, mechanical technology, electrical technology, and technology in the world of work with the purpose of imparting basic knowledge (theory) in correlation with practical work (practice) about the modern technological world. Similar efforts are also reported from the Netherlands, Greece, Ireland and Sri Lanka.

Working Concept of Technology

Despite the fact that various aspects of technology have been and are being treated as specialized fields in engineering, industrial arts, technical and vocational education, polytechnical education, arts and crafts, etc. in various institutes and schools, the concept of technology as part of general education, unlike science, is still fluid. The issue is further complicated by the existence in general education of a tradition of teaching a host of technical subjects and manual skills related to wood, metal and plastic substances, as well as needlework, sewing, cookery, etc. Such skills, useful as they may be in developing a technological enterprise, are insufficient to develop a comprehensive understanding of technology as application of knowledge to the solution of human problems. It is not surprising, therefore, that responders in many countries have problems in coming to terms with the subject and defining its place in the school curriculum and time-table.

Let us examine the two definitions related to technology appearing in Unesco's publications on "Glossary of Terms Used in Science and Technology Education" (1981) and "Terminology of Technical and Vocational Education" (1984). The latter defines technology in terms of 'technical and vocational aspects of general education' which refer to "those components of the general education curriculum which introduce pupils to elements of technology in order to acquaint them with the role of technology in contemporary life and permit them to develop basic skills in the manipulation of simple tools and materials. This element of general education is also designed for information and guidance purposes for eventual educational and occupational choices, but it is not intended to prepare young people for a specific occupation". It is further stated that ideas expressed in this definition apply equally to 'technology in the orientation cycle' in France, to 'polytechnical education' in the USSR and to 'industrial arts' in the USA.

Here the role of technology within the framework of technical and vocational aspects of general education may be accepted without argument but its concept as a means to developing practical skills in the manipulation of simple tools and materials is rather narrow and limited. It suggests that technology is merely a manual activity and thus belittles its importance as an educational tool in developing a person to live comfortably in the world of technology. Hence, in defining the scope and content of technology teaching, care must be taken to avoid the terminological confusion resulting from the tradition of teaching multitudes of technical subjects in the school. The integration of knowledge and skills as well as attitudes and values are useful in developing the concept of technology in general education which would be braod-based and relevant to individual and national socio-economic development needs. Such a concept should contribute to the total function of general education in understanding the three-fold environment of nature, society and man-made systems in an indivisible combination of science, technology and humanities. This brings us to the statement which appears in the Glossary of Terms (1981) and reads: "technology as the application of scientific knowledge to the general purpose of fulfilling an individual, community or national need.. Thus, airplanes, insecticides, cameras are direct products of technology, though often mistakenly equated to science by the general public". This definition introduces another angle of technology emphasizing application of knowledge to serve some general purpose. This implies that in teaching the subject, balance between the intellectual effort and the practical work is of great importance.

This view is further strengthened by the statement made by the Committee on Manpower Resources for Science and Technology in the U.K.: "in every technology the ultimate purpose is to exploit existing scientific explanation. On this basis, Schools Council Project on Technology defined technology as the purposeful use of man's knowledge of materials, sources of energy and natural phenomenon. The International Congress on Science and Technology organized by Unesco (1981) unanimously agreed that science and technology, together with the teaching of them through the various types of formal and non-formal education, constitute an essential factor in improving the material and cultural conditions of people's lives and a priority objective of cultural development. Para 110 of its final report reads "Technology education is a *sine qua non*, both to understand the scientific basis of techniques and devices, and also to acquire the requisite skills for productive work and efficient living in different societies..". These statements show technology to be wider than science and as having a vast influence on society and education.

In pursuing the pilot project on technology in general education (1981-83), the participating countries followed different approaches, for example, Australia aimed to develop positive attitudes towards making and doing rather than knowing and following instructions, as well as increasing students' capability for solving practical problems through technological means. The overall concern of the project was the general education for all students and in preparing teaching-learning materials, high priority was given to short independent exercises offering opportunities to design and test technological solutions to particular problems.

In India and China, an integrated approach to science and technology teaching was adopted as the basis of the project. In the latter, students were encouraged to understand the scientific bases of various socio-cultural customs and traditional agricultural practices through the teaching of medical biology and astronomy. In India, however, the project was designed to provide opportunities to students to work with materials and processes related to production and construction. It was also intended to encourage them to design and evaluate solutions in terms of human needs. Accordingly, modules were prepared on energy, friction, combustion, household electricity, electro-magnetic devices and wheat-to-biscuit combining technology with science education.

In the Philippines, the need for technology education was viewed from the point of view of eleven basic concerns of food, water, shelter, clothing, livelihood, health, education, culture, mobility, energy, ecological balance and sports, including recreation. Thus a teachers' guide and students' manuals on appropriate technology were prepared and supplemented with 'do-it-yourself' technology-cum-livelihood brochures for use both in and out of school.

In the Consultation Meeting (1984) the group regarded technology as an application of knowledge for making and doing purposeful or useful things, as well as an aid to understanding our technological environment. It aims at developing our ability to employ our resources for human benefit. Technology education may be considered as a means to find new and better ways of solving problems and satisfying our needs and comforts.

In the working paper for the International Symposium on the Teaching of Technology in the Context of General Education (1985) the following working definition, based on the study of over one hundred definitions of technology (Gebhart et al 1979), was suggested for consideration:

> "Technology is the know-how and creative process that may utilize tools, resources and systems to solve problems to enhance control over the natural and man-made environment to alter the human condition".

In discussing this, the symposium became unhappy about the concept of technology as "merely altering human conditions". It thought that the underlying idea here should not be so much to alter things but to improve them. Thus it was suggested:

> "Technology is the know-how and creative process that may utilize tools, resources and systems to solve problems, to enhance control over the natural and man-made environment in an endeavour to improve the human condition".

Thus the working concept of 'technology' becomes greater than technical and vocational education. It reflects ideas and characteristics such as knowledge, creativity, design, skills for utilization of tools and materials, use of resources and systems, problem-solving and decision-making, control of environment, both natural and man-made, improvement of the human condition, etc. Given their socio-cultural context they can be seen as worthy of inclusion in general education. As a matter of fact various countries such as the Netherlands (Kremers and Mulder, 1985); United Kingdom (Black and Harrison, 1985; HMI-DES, 1982) and Quebec (Government of Quebec, 1983) already reflect these ideas as basic to their objectives and programme activities for technology teaching as part of general education.

Technology as Linked with Science Teaching

The working concept of technology, broad and wide-ranging as it is, can assist in the exchange of ideas and experiences on the subject, or, more hopefully, can provide a useful starting point for countries developing technology teaching as part of general education. Programme details and approaches for the purpose will, of course, vary with educational goals, national objectives, socio-cultural requirements, financial resources, physical facilities including teaching-learning materials and qualified teachers in each country. Educators, however, seem to agree that teaching of technology, whether as a subject in its own right, or linked with other subjects, need not focus exclusively on high technology such as computers, nuclear reactors, invitro-fertilization methods or complicated processes contributing to specialized courses for technicians, engineers and other vocations. As component of general education of all, it should be sensitive to the aspirations and needs of the community. Thus it should provide the recipients with awareness and knowledge they need in everyday life in a way that reconciles practical work with an intellectual effort, as well as awakens their curiosity, rather than impresses them or scares them away.

During the last few decades, an extensive and radical process for broadening education has taken place. Moreover, under the pressure of expanding knowledge, various subjects in the school curriculum, almost everywhere, have become crowded. It has added additional constraints on teachers, and it has reduced the act of learning into a race for learners to cover the curriculum merely for the purpose of examination. Thus, addition of technology as a new subject may be resisted. Moreover, such a move raises the question of policy changes and administrative procedures involving acquisition of already scarce financial and other resources for education in developing countries. Again, a new discipline needs new teachers which, for technology teaching, are almost non-existant. This would also involve the problem of priority of existing subjects and their claim on the school timetable. And to make it an essential part of all subjects across the school curriculum is equally difficult or doubtful for the same reasons.

On the other hand, science and technology are in many ways indivisible and mutually interdependant for each other's advancement. As integral parts of our modern culture and socio-economic framework, science and technology represent two areas of human activity which, while fundamentally different, are related. The former signifies efforts associated with the natural human desire and curiosity to KNOW, UNDERSTAND, EXPLAIN or PREDICT some natural or man-made phenomenon. The latter, likewise, is also the result of the human's desire, but to find ever new and better xays of DOING things to meet various individual or community needs. Thus, the motivational force in science is essentially a desire to KNOW' while in technology it is a desire 'to DO'. However, within the framework of general education for life and living, it is too simplistic to think of science as theoretical and experiemntal, and technology as practical or applied. In meeting their various needs, ancient societies made no such distinction between science and technology, and modern society is more than convinced that it is bringing togenter of science and technology as an educational toool which will enable young people to understand them and their role in life and, hopefully, encourage them to consider ways of putting them to good use to serve human purpose.

It is recognized that learning is more effective if it is activity-based, i.e. if it takes place in the context of doing, with constant interaction between knowledge and its application in everyday life. In this manner, science teaching can be little divorced from that of technology. Similarly, technology teaching cannot be separated from the principles embodying the knowledge of science. Thus, in the process of education, whereas science will aim at providing information and experiences to deal with 'what is' or 'to know', technology will help in providing information and experience to deal with 'knowledge' or 'to do'. After all, in order to do something better, it is essential to know something more and vice versa.

National development needs are often defined by such concerns as natural resource conservation and development, health and nutrition, environmental problems, population dynamics, food production, development of life skills, and rural transformation. In this respect, the impact of technology in its diverse forms on the scientific, physical, cultural and socio-economic environment of all human beings is very significant and cannot be excluded from their education in science.

Under the circumstances, it is advisable to link technology with the teaching of science which is an accepted and established component of general education. This approach, while overcoming the disdain of technology in school education, will go a long way in making science education more relevant and useful in the life and living of the learners. Many scientific principles are embodied in technologies occuring in real-life situations of the learner, as well as the national devleopment concerns mentioned earlier. Project work in science education can provide further opportunities for understanding the operation of technology in solving problems to serve human purpose. This will, hopefully, help the majority of students pursuing science as part of general education to cope with life in an increadingly technology-based society of tomorrow.

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* The opinions expressed in the paper are those of the author and are not neccessarily those of Unesco.

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MAKING THE BEST USE OF THE KNOWLEDGE OF SCIENCE AND TECHNOLOGY THAT ABOUND IN THE DEVELOPING WORLD TO IMPROVE THE QUALITY OF LIFE THROUGH EDUCATIONAL DEVELOPMENT WITH PARTICULAR REFERENCE TO NIGERIA

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1 INTRODUCTION

The use of the knowledge of Science and Technology that abound in the developing World for educational development arises through the realization that there is abundant indigenous knowledge of Science and Technology in these parts that are manifest in the surival games played by peoples of the developing world. This is inspite of the advances already made in each of such areas throughout the world.

Nonetheless, these advances appear not to have had any serious affects on the people as modern science and technology crawl in their bid to catch up in these area. As a result of this slow pace, it has been realized that the most potentially beneficial bet towards development will be to identify, develop and/or adapt and use, and hence exploit the science and technology based knowledge and concepts which abound. For the people who inhabit parts of the world where modern science and technology have had no significant impact thus far, it is through such approach that meaningful progress in regard to development can be made. Although science is conceptualized as a process of thinking, a means of acquiring new knowledge, and a means of understanding the natural world, technology which is probably more ancient than science is conceptualized as the systematic knowledge of industrial arts which is primarily interested in the practical uses of scientific information derivable from the culture of the people.

Every people have a culture. That is to say we all have established ways of sharing and regulating experience that communities and groups evolve through common forms of the expression of beliefs, values and actions, and means of controlling and adapting to their material lives.

Williams (1983) contended that "the way in which we think about and understand the world around can quite properly be described as our culture." There are other facets of this concepts. Within historic time as much as at present, cultural distinctions have often been associated with styles and ways of farming, accepted beliefs and practices, imagination, intellectual versatility, inventions, artistic activities such as drama, literature, art and sculpture etc. Little wonder then that Maddock (1981) argues that "Science is a cultural enterprise, and as such becomes part of the formal educational scheme, as societies establish, expand and change their educational systems to meet the needs of their members."

Further, the Advisory Committee on the Application of Science and Technology to Development has also argued that:

> the growth of human intellect and skill is, in its very nature an assisted growth. In the deepest sense, a culture serves as an amplifier of the capacities of those who participate in it. The more technologically advanced the culture, the more certainly greater is its potentials for amplifying powers of the human hand, the human senses and human thought.

This is being the case some aspects of the Nigerian culture which appear to be relevantly geared, as of now, towards the amplification of the powers of the human senses, and especially the thought processes, may well be much more profitably exploited to achieve the above, if need be, in the context of survival, and development through education.
This means that the various cultural perceptions will be adequately conceptualized and developed through such exploitation. After all as Hooper (1971) contends, the "Curriculum" (which is all the learning experiences offered to pupils under the aegis of the School and yet goes beyond the subject matter taught)" is socially and historically located, and culturally determined." This follows the realization that changes in society bring about in time, changes in the educational system and vice versa.
It is largely in this context that this paper will deal with the need to cycle such knowledge of science and technology identifiable in Nigerian (rural) cultures for the purpose of rural educational development.

2 HOME BASED SCIENCE AND TECHNOLOGY

While contending that there abound a good deal of science and technology based knowledge in every traditional set-up in Nigeria and in other developing countries, a few examples under: Housing, Canoe (Boat) Making, Game Hunting, Dental Care, Soap Making, Brewing and Distillation of local Drinks, Plants and Medicines, Pottery Making, Palm Oil Preparation and Instruments to Produce Sound: The Drum, will be discussed.

One of the activities in which knowledge of science and technology manifest in the Nigerian rural culture is in housing. This is so as the people appreciate the types of materials used in the construction of houses. For example, sand, clay (earth), woods and ropes used are selected on the bases of their knowledge of some scientific and technological Principles.
From the technological viewpoint, they determine the shapes, sizes, strength and durability of the materials. Also, the amount of ventilation needed, the need for temperature control and that of light for illumination required are equally appreciated in the house construction business. These can serve as the bases for further development in the area of housing in rural cultures.

Another area in which knowledge of science and technology manifest in the developing world is in Canoe (Boat) Building. For the rural cultures where lakes, rivers or even seas and oceans abound, communication is achieved largely by canoeing. In effect, canoes have to be constructed for effective communication. The procedure for boat construction calls for and have scientific implications especially in the types of trees to be felled and used, the shaping of the canoe and the hollowing by employing fire to burn out the interior.
They appreciate that heat causes expansion which derive from physical science. Also appreciated is the science behind the systematic burning leading to the expansion of the canoes to achieve the deserved stability, balance and hollow to float. This is to say that they know when and where higher temperature may be be maintained.

The third activity under consideration which is known to draw on the knowledge of science and technology in game hunting. This knowledge has enable people in rural communities to show comparatively advanced skills than prevailed in the very rural and primitive folklore of the "Saber Tooth" approach.
The improved skills which derive from need have both scientific and technological implications and applications.

The advances include the use of the traps which tie up the foot of the animal as the game triggers off the system. Other methods include the digging of trenches which are camouflaged by a light surface layer of fallen leaves on the regular game tracks to trap the animals. For others, cages made of wood and cane-ropes are set with baits which attract and trap the games. These are in addition to other modern game hunting methods which cannot be fully enumerated in this paper due to the constraints imposed by space.

In the developing cultures, dental care is very highly revered. This care is achieved through the use of chewing sticks. The effects or usefulness of chewing sticks in place of tooth brush and paste have amazed many a dentist. Many attributes have rightly been associated with the use of chewing sticks and these include: making the teeth white and fragrant, strengthening and giving vigour to the gums and teeth, cleaning the teeth by mechanical removal of plaque as well as providing many medicinal substances that can protect the teeth from decay, remove the "tartar" as well as stimulate the gingiva and heal spongy bleeding gums.

Selection of the safe plants for use as chewing stick is a highly scientific feat. Some may have been identified on trial and error bases while knowledge of others are handed down from generation to generation. The trial-and-error process in normally scientific and can serve as a means to educational development and survival in the developing world.

The chemical contents of these plants deserve further investigations as to identify what in them do the trick.

Another activity in the traditional cultures which draw on knowledge of science and technology is in the soap industry. Soap making has been going on for many centuries in different parts of the world including rural communities of Nigeria, using local knowledge, skill and materials such as palm oil and banana ashes and others. The scientific and technological knowledge in soap making has modern scientific and technological implications and flavour which have enabled it to thrive over the years. The raw materials lead to the provision of the necessary alkaline medium which reacts with palmitic or stearic acids to give the soap. All these go to support arguments that substantial amount of knowledge based on scientific and technological applications exists in developing countries. The process is as good as modern even though it involves the local production of all the necessary raw materials and producing the soap by saponification. Although the products are crude, they still serve the purpose of cleaning and washing up clothes and human body, and other materials such as plates etc with scientific and technological precision.

One other activity undertaken in Nigerian rural cultures and which is highly scientific is brewing and distillation of local drinks. Brewing and distillation of beer and other forms of drinks prevail in almost every country. While some employ very sophisticated methods and processes, other in the developing countries including Nigeria brew their own special beer or liquour (arrack) by fermenting locally obtainable materials by localized yet sophisticated processes. The brewing and distillation process as in the use of basic methods and principles as employed in advanced countries, "... show some evidence of modern technology as the kettle is a large oil drum, while the condenser is a pair of narrow copper-tubes wound into a coil", in the words of Williams (1982). In the very rural areas, the bamboo is however, substituted for the copper tubes and the drum substituted with wooden troughs.

In Nigeria, especially in the delta States, brewing and distillation of local beers and/or arrack (gins) remains a long standing tradition. The raw materials is the sweet milky alcoholic drink or wine obtainable from both raffia palm tree or oil palm tree (Elaeis guineensis) which grows wild in the tropical rain forest. The abundant distribution of these trees results in the drink being a constant and regular source of income and entertainment for the people. As Williams (1982) further suggests "the way of life of people of developing countries is intensely impregnated with scientific concepts", thereby re-affirming the thought or conviction advocated in this paper.

Another very useful area worthy of discussion is in Plants and Medicines. For thousands of years, man used what was very much at hand, plant, to form natural cosmetics, remedies and preventives. The secrets of the plants are handed down generation after generation. Although traditional medicine appears to be losing credence especially with advocates of 'modern' medicine, people in the developing world still depend on them. There is thus increasing evidence that plants have medicinal value in sweetening alcohol breath (sweet flag), in preventing high blood presure (wild leak), as a laxature or for abortion (cotton root), against rheumatism (orange root), in paralysing worms in the stomach (West Indian Goosefoot) and against cold and fever (wild potato vine). Some neutralize stomach acidity, paralyse or prevent conception. While many others used in wrong doses kill the over-dose users. Indeed, there are so many others in the developing countries.
In effect, people of the developing world have virtually lived and/or survived on the knowledge of science and technology which exists in their various cultures and manifested as well in the use of traditional medicinal plants (folklore remedies).

Pottery Making is another cultural activity in which knowledge of science and technology manifests. In places or communities which can hardly to be described as rural, pottery making is part of the everyday life.

The skills, the thoughts, planning, and the amount of preparation needed to produce these potteries suggest a good deal of knowledge founded on science and technology. As Williams (1982) points out:

> Producing pottery is a community effort-everyone has job to do. The skills are handed down through families but are not exclusive to any one family.

In effect, the material, clay, is locally obtained, worked with the feet, and mixed with millet chaff especially in the northern parts of Nigeria. Great care is taken to remove seeds and stones.
By lifting the edge of the mat, the flattened heap is turned, sprinkled with chaff, trodden down over and over again. Water is added as nacessary until a soft but unsticky consistence is achieved. Then the moulding commences by a second worker taking a lump of clay and wedges it on his mat.
The process is best undertaken than described as at the end a beautiful pottery results. Variety of potteries are made; some provided with lids.
At last, the pots are fired in kilns made of clay, dung and straw-simply a circular wall. The kilns are filled with earthenware and fired once a week in time for the markets. The entire exercise entails a great deal of knowledge of science and technology put into action for the benefit of man.

Palm Oil preparation, is one main activity undertaken by people in the developing cultures in which knowledge of science and technology is highly manifested. Palm oil is very much prepared industrially in many parts of the tropical world yet in the rural areas the techniques employed draw on clear knowledge of science and technology.

The oil palm tree (Elaeis guineensis) grows tall and wild in tropical forest regions of the world. In the developing world, the palm fruits are collected by climbing the tree with a specially woven rope which allows the climber to use his hands freely yet very well secured while high up on the tree. The bunches are then cut down with pointedly sharpened matchette.

These palm bunches are brought home on the head or strapped on the two ends of a carved wooden bar and carried on the shoulders. When one shoulder tires under the bar with its load it is transferred to the other with a speed, tact and precision which is better observed than described.

Extracting The Oil:

The palm fruits are picked up and boiled in large barrels or drums for length of time which vary from 5 - 10 hours depending on the quantity in the barrel and the intensity of the heating by firewood aided by the chaffs and/or empty bunches etc.

The oil is extracted by transferring the boiled fruits into specially carved wooden trunk (trough) and trodden upon by groups of young men. Some protect their soles by wearing specially made wooden or metallic heels. Water is then added to cause the oil to float. The oil is decanted into a standby barrel where it is boiled for about four hours and subsequently filtered and the oil is traded away for cash in exchange for other goods (barter).

The Nuts and Kernel:

The nuts are cracked to obtain the palm kernel which is used locally for further production of oil by roasting. The process of obtaining the kernel is rather tedious even though this process has very clearcut scientific implications.

The cracked nuts and shell (the stony endocarp) are poured into a large wooden trough dug out of a tree trunk of into dug out rectangular pit of about 10 feet by 6 feet and 4 feet deep. Mud is added to it along with large quantity of water.

The idea is to increase the density of the water to enable the kernel float. This tradition (knowledge) has been with these cultures for centuries as they were handed down from generation to generation. And clearly they have achieved some success because their knowledge hinged on science and technology.

The last activity which people of rural cultures especially in Nigeria undertake and which clearly has knowledge of science and technology manifest in it, is the production of the drum to produce sound. Naturally, sound (which is the sensation experienced when the brain interprets vibrations within the structure of the ear by rapid variations of air pressure) can be obtained when vibration is caused. In effect, sound is made as two objects are struck together and this may appear to be a common knowledge. But to vary the sounds to obtain high or low pitches requires intelligence and some knowledge which can rightly be described as scientific.

In the developing countries, various instruments which produce sound are made with drum as the most common one. The necessary materials used are tree trunk, animal hides and skin, and cane ropes.

When the tree trunk of about half a meter along is cut, the tree trunk is bored by any means. Usually, fire is set to the trunk and controlled. Local blacksmiths produce axes, chisels and hummers which are also used in the boring exercise. After boring, the tree trunk is carved down to reduce the outer circumference and into desired shape. The animal hide or skin soaked in water to soften is placed over the now hollow trunk. At this point, two cane ropes woven into bands are worn over the hollow trunk and further ropes are use to bridge them together.

Then the hide or skin is neatly strung to the upper band. At this point, the drum is virtually ready except that pegs will be stuck between the hollow trunk and the lower band which is hammered on to provide the tautness required to produce a desired pitch. The more the tension achieved the finer or sharper the sound obtained.

The significance of this lies in the fact that it provides the bases and justification for the claim that a great deal of knowledge founded on science and technology existed. Cultures of the developing nations including Nigeria enjoy a good deal of patronage of the locally available technology and science. At the moment, however, there is a rapid drop in the patronage enjoyed as a result of the speed with which locally available technology is being destroyed by Western technology.

3. CONCLUSION AND RECOMMENDATION

From the account given thus far on the types and quality of knowledge of science and technology that are prevalent in the developing countries, it is little wonder that the world's population has more than doubled within the last one hundred years especially in the developing world.

This is clearly attributable to the unexpectedly high quality of life that people in the very areas of the developing countries live. They have, in effect, been utilizing the knowledge that abound within and around them to their advantage. One way by which these scientific and technological achievements in rural communities can be appreciated must be by rating their efficiency levels in terms of meeting the needs for their procurement, development and serviceability, and possible replacement. Virtually, all that have been presented above have the ability to be replaced at minimal cost in the rural areas.

Houses made of grasses amd mud (earth) are repaired and often replaced through communual help by relatives of the residents of such houses. This is usually in reciprocation of similar but probably earlier assistance. It is also appreciated that all other scientific and technological achievements of various cultures of the developing world are readily replaceable. The fact that the knowledge is transmitted largely through apprenticeship is the most serious setback encountered. This leads to some knowledge of science and technology being lost or abandoned through poor communication or dissemination of such knowledge. Quite a good number of locally patronized scientific and technological feats must have been lost through this defect.

To stem the rapid losses encountered in this way, it is the intension of this paper to advocate a closer study of any such identifiable, scientific and technological feats for documentation, modernization and possible adoption for the educational development of young persons in the developing world.

This author further advocates the ready adoption through refinement of these achievements in a bid to improve the everyday life situations in relations to the use of technology, consumer products, good health care, more nourishing food and improved environment.

One overriding conclusion that can be drawn from these scientifically and technologically justifiable developments in terms of survival gains made by us through the use of such knowledge would naturally be the advocating for better ways of appreciating these achievements. This follows a realization that they are undervalued as they are rather compared with the highly advanced western science and technology on the basis of which they certainly do not deserve to be compared. They should rather be seen from their success or merit point of view.

It may be necessary at this point to suggest that educational programmes which must be based on the knowledge of science and technology that abound in the developing countries be developed and adopted for use as a means of achieving better quality of life in such areas.
As may have been appreciated, advances in western science and technology have had some significant impact in the quality of life of people in the developed as well as developing world. But as I have aready pointed out, these effects are felt very minimally in the very rural areas where the knowledge of science and technology that have been discussed above prevail. It is in this light that a number of options may be highlighted. These options include the development of:

- Educational programmes to help develop the relevant skills to advance the knowledge highlighted.
- These can be achieved by a practical problem-solving approach. This will aim at involving young pupils to the extent that their readiness permits, in all the development phases of any recognized science and technology based products.
- Pupils may commence the advancement of these by embarking on projects which will attempt to identify and document all such achievements.
- The next stage will then be the development of these potential projects into steps and identification of relevant materials and skills needed, and the designs of each procedure.
- The next stage will be principally to identify their equivalents in modern science and technology as a means of ensuring that they can earn some recognition.
- Evaluation of these can be based on outcome (products) which must be appreciated from fow they meet the need for their existence.

It is pertinent at this level to point out that much work has been undertaken by Professor Iolo Wyn Williams of the University College of North Wales, in Bangor, U.K. in this regard. But it appears to be the beginning of the recognition of the fact that a good deal of knowledge which can justifiably be appreciated even from the point of view of western science and technology abound in the cultures of developing countries.

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PRE-UNIVERSITY EDUCATIONAL SYSTEM IN NIGERIA

Pre-University education in Nigeria consisted the 6-5-2-3 (six years of primary, five years secondary and two years of higher School Certificate (HSC/A'L) and then three years of University education). Recently, however, the system has changed to the 6-3-3-4 (six years of primary, six years of secondary of which the first three constitute the Junior Secondary and the other three, the Senior Secondary, and four of University education. What has been altered is the structure, not the total number of years. While on the content, the emphasis has shifted to those subjects that would make the products of the said educational system easily employeable or self employed probably through the expliotation of existing knowledge of science and technology.

The approximate ages of pupils in the primary School up to when they are due to be admitted into secondary Schools by common entrance examination is 11 +. In effect, by age 16 or 17 pupils are expected to have completed the dual stage secondary education. The mode of assessmant into the University is by a common entrance examination known as the Joint Matriculation Examination (JME).
This paper, in my opinion, fits into all the levels of education but probably most suited to the secondary educational system and in content area.

AUTHOR'S BRIEF AUTOBIOGRAPHY

This author hold the following qualifications West African School Certificate (WASC), Nigerian Certificate in Education (NCE), Advance Diploma in Educational Studies (A.D.E.S) in Wrexham, Wales, U.K. Bachelor of Education (Science Education) with honours (Wales), Magister in Education (Wales), and Ph.D. (Science Education - Wales). Presently, I am a Lecturer in the Rivers State University Of Science and Technology, Port Harcourt, Nigeria. I worked under the Ministry of Education before joining the University.

TECHNOLOGY FOR RURAL DEVELOPMENT: AN INDIAN EXPERIENCE

Saurabh Chandra (Banda, U.P. India)

1.0 OBJECTIVES OF RURAL DEVELOPMENT

1.1 Planners in India have enumerated the following objectives of planning whose achievement is essential for rural development :-

(a) Removal of unemployment and significant reduction of under-employment.

(b) an appreciable rise in standards of living of the poorest sections of the population; and

(c) provision on uniform basis for all people, of the basic needs like health care, potable water, education, rural housing, rural power supply, rural communications etc. through the creation of infra-structural facilities.

1.2 The twin objectives of alleviation of poverty and reductuion in unemployment through the developmental process have been the sheet anchor of the strategy aiming for rural development. In brief, these can be termed as growth with social justice. Growth, pe se, is inadequate because numerous field studies in the agriculture sector have shown that the gains of development on account of application of technology have flown in proportion to the existing asset holdings. In rural India, the asset, income and consumption distribution patterns are highly skewed. According to the agricultural census of 1980-81, small and marginal holdings (area less than 2 ha) were 66.60 million in number (74.5% of the total number) operating an area of 42.76 million hectares (26.3% of the total area) whereas large holdings (area more than 10 hectares) were 2.15 million in number (2.4% of the total number) operating an area of 37.13 million hectares (22.3% of the total area). About 40% of the population or about 300 million people live below the poverty line, have a per capita income of less than 100 per annum. About 30% of the population accounts for over 50% of the consumption expenditure. It is estimated that by 2000 AD, 250 million persons will have to be employed in rural India. To meet this demand over 100 million additional jobs will have to be created.

1.3 Poverty is thus the central problem that will have to be tackled to ensure rural development. For its alleviation, its root causes must be identified. Poverty is the fall-out of the inaccessibility of the poor to income generating productive assets, lack of gainful wage employment and diversion of rural resources to meet the investment needs for elite cunsumption through the market process. Planning process seeks to tackle this problem by attempting to ensure that incremental increases in the size of the national cake are distributed progressively.

2.0 Why is technology the only real answer to the rural development conundrum ?

2.1 The battle for rural development and against poverty is ultimately fought at the level of programmes. These programmes can be divided into two categories :-

(a) institutional programmes which involve re-distribution of land and non-land assets, re-organisation of the productive system, ensuring access to inputs, skills etc. and

(b) technocratic programmes which are production oriented and based on the use of new technology.

2.2 Development experience suggests that the role of institutional programmes in alleviating poverty is limited. Re-distribution of assets is the main component of institutional programmes. Land is the most important asset in rural areas. Further re-distribution of land through the implementation of land reforms programmes is unlikely to yield significant results. Strong organisations and economic strength of the disadvantaged groups is an essential condition preceding the re-organisation of the productive system. Such a condition does not exist. The importance of institutional programmes viz. ensuring access to inputs, skills etc. is that they create a suitable atmosphere for application of technology and act as catalysts for technological advancement.

2.3 Consequently, the strategy for poverty alleviation has to be primarily based on technocratic programmes viz.

(a) increasing production, productivity and employment potential from land through multiple cropping practices, scientific use of inputs, improved agricultural practices and application of post harvest technology. Since modern technology is neutral to scale, the institutional conditions must ensure that benefits accrue progressively to small and marginal farmers and agricultural labourers, i.e. the sections who together with the rural artisans form the core of the rural poor.

(b) Scientific harnessing of animal husbandry and fisheries resources and forestry produce; and

(c) development of rural industries particularly in the cottage sector. Particular emphasis shall have to be paid to the upgradation of skills and techniques of village artisans to enable them remain competitive. As estimated by the National Commission on Agriculture, this sector will have to provide employment to 30% of the labour force, i.e. 75 million persons by 2000 AD. Thus 50 million additional jobs will have to be created in this sector.

2.4 The important role played by science and technology in increasing agricultural prosperity is best exemplified by the impact of "Green Resolution" in Punjab and Western Uttar Pradesh. With the introduction of High Yielding Varieties of wheat, production doubled in a short space of 5 years thereby transforming a subsistance agriculture into a commercial one. As a result,15% of the area under cultivation accounted for 53% of the increase in foodgrains production during the last 20 years. Surplus capital was invested in Khandsari and mentha plants and other small scale industries. On account of resultant adverse demand supply labour equation, migrant labour from the labour surplus regions is engaged in large numbers during the peak agricultural operations season in these areas.

2.5 The success of the dairy movement based on the cross-bred cow in Gujarat, sheep and rabbit wool production programme in Himanchal Pradesh, fisheries in coastal states like Kerala and Tamil Nadu is largely due to the impact of technology. Increased productivity in production sharing cottage industries like carpet manufacturing, saree production, handloom weaving, engineering goods etc. are other examples of improved prosperity based on innovative technology.

2.6 Ultimately increased productivity alone can lead to improved prosperity whether in the primary, secondary or tertiary sector. Technology is an essential condition for increasing productivity.

3.0 CHARACTERISTICS OF APPROPRIATE TECHNOLOGY

3.1 According to Bertrand Russel, science may be regarded as having two functions :-

(a) to enable us to know things
(b) to enable us to do things

3.2 The second function results from the application of the theoretical discoveries. In this paper we are primarily concerned with the second function i.e. the applied or the technological aspect. A lot of debate centres around the characteristics of rural technology. Schumacher termed it as intermediate technology. Most call it appropriate technology. However a few common characteristics of this rural/intermediate/appropriate technology which is particularly relevant to the rural industries sector (henceforth called appropriate technology) can be pointed. Appropriate technology is such that :-

- it makes the available resources most productive and at the same time creates the most jobs
- as Drucker put it, it is neither the biggest nor the smallest nor the one as was believed in the 1950's or 1960's, the one that absorbs the most capital. Both this as well as the one that absorbs the most labour is wasteful of scarce resources
- place of employment as a result of its application should be in rural areas, so that a spatial shift of rural poverty to urban areas is avoided
- production should be based on the use of raw materials available locally. In addition marketing of finished products in the neighbourhood should be possible
- production methods must be relatively simple so that the uneducated rural poor can easily adopt it through exposure to short duration training programmes

3.3 Thus the development of appropriate technology is largely based on the following assumptions :-

(a) it is possible to develop technology for production methods which will not only be cheaper than what has been developed in the technologically advanced countries but also be far more productive and
(b) output of an idle man is nil whereas the output of even a poorly equipped man is positive
(c) once its beneficial aspects are evident, even an uneducated poor man will adopt it
(d) media for transfer of technology exist

3.4 There are two other aspects of appropriate technology which have generated a lot of debate - the appropriate place for its development and the mechanism and the media by which it can be transferred to the end users. It is now realised that research for improving productivity in agriculture and other related subjects like silviculture, pasture development etc. will have to be carried out in research institutions. On the contrary improvement in agricultural implements, artisans tools, bio-gas plants, soil conservation and water management practices, to quote a few example, have to be carried out in the field. The user is in the best position to carry out the innovations because he knows exactly where the shoe pinches. Technological improvements to increase the effectiveness of mass-manufactured inputs like fertilisers, pesticides etc. with a concomitant reduction in their cost and toxicity shall be the domain of the manufacturers in-house research effort. Transfer of technology from the innovators to the users is the raison d'etre for its development. This requires development of an efficient transfer system whereby the evolution of suitable messages and using a judicious mix of traditonal and modern communication media, information regarding technological development can be transferred effectively to millions of users scattered in geographically heterogeneous and isolated regions.

4.0 WHERE AND HOW CAN APPROPRIATE TECHNOLOGY BE APPLIED?

4.1 The rural sector can be broadly clasified into :-
(i) the agricultural sector
(ii)the non-agricultural rural occupations sector which consists of animal husbandry and fisheries, forestry and above all the rural industries sector

4.2.0 AGRICULTURE SECTOR

4.2.1 Agriculture is the major component of the national income. More than 40% of the national income comes from it. It provides employment to about 70% of the total population. Besides being the source of food and nutrition for the entire population, it provides raw materials for the industry, employment for the bulk of the population, capital for industrial investment and foreign exchange earnings. The National Commission on Agricutlure has estimated that by 2000 AD, foodgrains production shall have to rise to 225 million tonnes from the present 150 million tonnes and this sector will have to provide employment to 70% of the rural labour force i.e. about 175 million persons.

4.2.2 Foodgrains production is the major component of the agriculture sector. Increase in foodgrains production has been slightly more than the increase in population. Technological break-through in production has been largely confined to wheat in the irrigated tracts. Paddy and Sorghum among food crops, pulses and oilseeds are the core areas for scienctific research to make quantum jumps in production a reality.

4.2.3 Technological advances resulting in land augmentation constitute the basis of land use policy. This has two components viz. reclamation and development of land out of use and multiple cropping. By 2000 AD, the National Commission on Agricutlure has estimated that the cropping intensity wil increase from 1.23 to 1.38 in irrigated tracts and 1.16 to 1.30 in dry tracts.

4.2.4 Water is the critical input for increasing productivity. 70% of the area in the country is cultivated under rainfed condition. This area would go down to about 50% by 2025 AD. These areas contribute nearly 42% of the total foodgrains production, 92% of pulses and 90% of the oilseeds. Thus technological break-throughs in dry farming methods is the critical challenge area. A few areas suitable for application of technology are as follows :-

(a) Soil conservation methods like gully plugging, contour bundhing, construction of submergence and water harvesting bundhies together with harvesting all the rain water in a watershed by means of check dams and tanks is being practised in the drought prone areas. In the state of Tamil Nadu, 40,000 tanks irrigate about one million hectares. Since they are unable to meet the exacting water demands of High Yielding Varieties, the need is to modernise them through structural improvements and scientific water management practices.

(b) To ensure optimum utilisation of ground water resources, Remote Sensing Techniques must be used to prepare district-wise inventory of ground-water resources. Based on the re-charging rates, detailed water utilisation plans can be drawn up. Conjunctive use of ground and surface water will prevent the depression of water table and diminish the problems of salinity and water logging.

(c) 67 mha irrigation potential has been created against a maximum of 110 mha. The bulk of this difference has to be created by harnessing surface water. For this, large dams using 'state of art' technology as in the case of Tehri Dam will have to be adopted.

The objectives of irrigation policy can thus be summarised as follows :-

- in irrigated areas, resort to multiple cropping to maximise production per unit area
- achieve maximum output per unit of water in medium and low rainfall area by ensuring irrigation of maximum area during rainy season
- protection of maximum area possible in areas affected by drought
- conserve water, soil fertility and germ plasm of plants and animals.

4.2.5 Ultimately, as mentioned earlier, increase in productivity is the key to prosperity. Studies have shown that there is a positive correlation between productivity and stability of yield. Other measures to increase productivity are as follows :-

(a) evolution of suitable high yielding varieties for each crop suited to the peculiar agro-climatic regions. Genetic engineering which involves re-combination of favourable genes through the transfer of genes from one species to the another is the current area of research.

(b) development of low cost soil testing methods to accurately identify nutrient deficiency, particularly that of micro-nutrients in the soil to enable them to be compensated.Efforts to control leaching in the Kharif season development of low and inorganic substitutes for inorganic fertilisers like anhydrous ammonia, improved efficiency of application of organic manures and biological nitrogen fixation by symbiotic and non-symbiotic mechanisms are some of the other measures that can be adopted.

(c) pest control methods must aim at evolving pest and disease resistant varieties,treatment of seeds before sowing, an efficient surveillance and early warning system to enable prophylactic and curative spraying and check them through biological means and agronomic practices

(d) develop techniques which will help to improve productivity continuously without a concurrent loss in the efficiency of conversion of cultural energy into digestible energy, which will at the same time maximise the beneficial effects and minimise the harmful effects of the new technology and which will improve utilisation of solar energy and reduce photo-respiratory losses by genetic or chemical means

(e) meet farm power needs through non-conventional decentralised sources like bio-gas plants, wind-mills, solar energy agricultural wastes etc., improved and efficient utilisation of man power and draught animal power using improved implements like iron ploughs, tyre yoke, modified sickle and spade, foot-operated pump, bullock operated bamboo tube-wells, replacement of diesel pump-sets by electric pump-sets and by development of past harvest technology.

4.3.0 NON-AGRICULTURAL RURAL SECTOR

4.3.1 This sector is composed of the animal husbandry and fisheries forestry and rural industries sub-sectors.

4.3.2 The objectives of the animal husbandry and fisheries programme are diversification of the agricultural production base, improvement of human nutrition, increased employment, opportunities and providing additional income to the weaker sections of the rural community. To achieve these objectives, productive potential of livestock, poultry and fishes must be improved by tapping the hybrid vigour of both indigenous and exotic varieties. Frozen semen technique for crossbreeding cows has achieved remarkable break-throughs. This must be backed by scientific pasture development (including tapping of non-conventional sources of feed) and husbandry practices (including health cover) to tackle the various problems of the new genetic strains.

4.3.3 Improving the productivity of forests by their scientific management to enable them meet the exacting requirement of raw materials for forest based industries, small timber, fuelwood and fodder for the rural community and maintain the delicate ecological balance (including its restoration wherever disturbed) are the avowed objectives of the forestry policy. According to it, 100 million hectares should be under forest cover. Estimates show that only 30 million hectares is actually under forest cover. To achieve this target by 2000 AD, 5 million hectares of land should be brought under forest cover every year. The critical bottle-neck is the requirement of 10 billion saplings for plantation every year. Modern bio-techniques of tissue culture which enables large scale multiplication of disease resistant varieties, along with development of suitable quick growing fuel and pulp varieties e.g. annual strains of bamboo for farm and social forestry appear to be the only viable solution.

4.3.4 The National Commission on Agriculture has estimated that the rural industries sector will have to provide employment to 75 million persons by 2000 AD. Schumacher has called for the creation of millions of work places in rural areas based on the application of intermediate technology. Drucker terms the creation of jobs for large masses of young people as a matter of survival for this country. Nilkantha Rath calls for the creation of massive wage employment opportunities, both on private and public account in rural areas. Thus there is unanimity on the importance of the rural industries sector for providing productive employment to the rural poor. Regarding the nature of the industries, based on the examples of non-Communist Chinese Societies and South Korea, Drucker identifies these as investment in production sharing and labour intensive stages of manufacturing production whose output is marketed in developed centres. To this can be added the burgeoning domestic market of manufactured wage goods, particularly if conscious efforts are made to increase the purchasing power of poor. A few examples of former are the carpet industry and engineering goods industry whereas the improved spinning wheels, hand and powerlooms, rural soap,Khandsari and briquetting industry are few illustrations of the latter.

5.0 Why and how can technology be applied for the development of infra-structural facilities ?

5.1 Creation of infra-structural facilities is a conscious effort to ensure that the benefits of social services reach the poorest sections of the society with the objective of improving their cunsumption level based on the theory that neither growth nor social consumption can be sustained without being mutually supportive.

5.2 Rural infra-structural facilities encompass the fields of education, housing, health, roads, water supply and electrification. Low cost houses using unfired compressed bricks and locally available thatch treated to prevent fungal attack and for fire proofing is the only way to meet the Minimum Needs Target of 3.50 million dwelling units for Rural Landless Labourers' families; 24,000 sub-centres, 10,000 primary health centres and 1500 community centres for health care and for school buildings. Education is an essential input for development. Satellite Instructional Television Experiment (SITE) was a resounding success. For the development of rural technology, basic scientific principles must form a significant portion of curriculum in formal, non-formal and adult education programmes. Investment in rural health care for improving the productive potential of man power should start with low cost population control methods. Laprascopic technique for female sterlisation has led to improved achievement. Universal immunisation needs safe modern methods for transportation, storage and application. Flush latrines and soaking pits improve sanitation and prevent the spread of communicable diseases. Use of sand and charcoal filters along with the coverage of the remaining 39,000 problem villages by hand pumps and piped water will reduce the incidence of water borne diseases. Finally, connecting 24,000 villages by road and electrifying 65 percent of the villages by 1990 calls for techniques which will not only reduce costs but also increase durability and lead to improved management.

6.0 EPILOGUE

6.1 In this paper, an attempt has been made to highlight the importance of rural development and the role of technology can play in it. The few examples cited are at best illustrative. Many more find no place in this paper. The technological renaissance has begun. Efforts in this direction if supplemented by more community participation, greater emphasis to reduce inequalities along with a continuous debate on the course technology is taking and the application of mid-course corrections if any are required, should carry this revolution to its logical fructification. Care must however be taken to ensure that the innovations are in consonance with the prevalent value systems. A harmonious blend can only generate optimism about the future prosperity of this country in which every one has a stake since poverty in the long run is indivisible.

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TECHNOLOGY IN PUPILS' EVERYDAY LIFE. EFFECTS OF COURSE MATERIAL ON THE PUPILS' ATTITUDE TOWARDS TECHNOLOGY

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Summary

Technology plays an important part in society. The way we travel, work, spend our leisure time is influenced more and more by technology.
It is desirable that this is reflected in education: every pupil should learn something about technology in his/her education.
In our group Educational Physics at the Eindhoven University of Technology we do research and development work into the place of technology in education. We have several projects. The project Physics and Technology (P&T) we are responsible for has three main activities:

- Research into the *pupils' concept of and attitude towards technology* and the role technology plays for the quality of life,
- research into the *meaning of the concept technology* according to experts, especially technology in education,
- development and evaluation of *course material about characteristics of technology* and about the impact of technology on everyday life situations, to be used in physics and other lessons.

0. Introduction

Technology has a great impact on the quality of life. Our society is more and more influenced by technology. Therefore we think that pupils should learn about technology in secondary, and also in primary education.
There is a second reason: many professions pupils can choose are of a technical kind. To be able to make their choices well pupils should hear about technology and technological professions at school before they make them.
More attention in education for technology can be realized in a number of ways (Black and Harrison 1985), two of which are:

-> introducing technology as a separate subject for all 12-15 year old pupils,
-> paying explicit attention to technology in other subjects.

In the Netherlands a discussion is going on now about the content of a new subject *technology*. The government has reacted positively on an advice to introduce such a subject in secondary education. But there is still uncertainty about what the content of such a new subject should be.

In the project Physics and Technology (in Dutch: Natuurkunde en Techniek, abbr. N&T), we do research and development-work with reference to technology in education. Prof.dr. Jan H. Raat is supervisor of the project, drs. Marc de Vries is project-leader, drs. Falco de Klerk Wolters and drs. Rosy van den Bergh are co-workers.

The project consists of *three activities* (also see the article of Raat and De Vries in Phys.Ed. 1986):

1. research into the attitude towards and the concept of technology of pupils of various schooltypes and of various age-groups; this research got an international extension,
2. research into the contents of the concept technology according to experts, particularly the concept technology for education,
3. development and evaluation of example-courses, in which the characteristics of technology are dealt with, based on examples from daily life.

In this paper each of these three activities will be discussed in the context of the theme of the symposium: technology and the quality of life.

1. Pupils' ideas about technology and the quality of life.

By taking up technology in the curriculum we are trying to achieve that pupils get an idea of what technology is and what role technology plays for the quality of life. What we are primarily concerned with is not all kind of detailed knowledge, but insight in the general characteristics of technology (this is also stressed in several contributions in Traebert et al. 1979-1985).

We furthermore want the pupils to adopt a positive-critical attitude towards technology. Pupils also ought to see the place of technology in their daily life.

This applies to both girls and boys. The field of technology is often regarded as something particularly suited for boys/men. We want to correct this distorted view.

To fill the education in technology in such a way that it gives pupils a fairly balanced concept of technology, it is necessary to know what the pupils' concept is at the beginning of technology education. This also applies to their attitude. After the technology-lessons we need an instrument to evaluate the result of the lessons on the pupils' attitude and concept. Little research has been done in this field (Angele 1976, Breakwell et al. 1986, Moore 1984, Nash et al. 1984, Weltner et al. 1980. A lot of research has been done into the pupils' attitude towards science (Schibeci 1984), far less into the pupils' concept of science, and very little into the pupils' concept of and attitude towards technology.

Within the framework of the project Physics and Technology we developed a questionnaire with which this can be measured.

This questionnaire consists of 88 items of the Likert-type. In the first PATT-Newsletter (PNL 01, June 1986) a full description of the scales and items is given.

The first part of the questionnaire measures the following six components of the attitude: interest in technology, gender and technology, consequences of technology ('technology and the quality of life'), difficulty of technology, technology in the curriculum, technical careers. Each of these scales contains 10 items.

The second part measures the concept of technology (the names of the scales shall be discussed in greater detail in section 2): technology as a human activity in society (10 items), technology and science (6 items), designing and other technical skills (7 items), dimensions of technology (matter, energy and information)(5 items).

To get additional information and also for the validation of the results of the Likert questionnaires, we used essays.

With this instruments we did research among 5,000 pupils of about 13 years old in the second form of secondary general and vocational schools in the Netherlands.

Important results are:

-> pupils have a distorted concept of technology. They are far more inclined to think of the product-side (equipment, machines) than of the process-side (designing, making and using things). This goes for girls even more than for boys,,

-> their attitude if fairly positive, but this applies significantly more to boys than to girls,

-> there is a high correlation between attitude and concept.

Now we make some remarks about the pupils' ideas about technology and the quality of life. Pupils have rather different views of the importance of technology in society and of its impact on daily life. This becomes evident from the information of two scales: the 'consequence' scale and the concept scale 'technology as a human activity'. Particularly between boys and girls and between pupils of different level of schooling there are significant differences. What these differences boil down to is that boys have a better concept of the relation between technology and the quality of life, they also have a more positive attitude towards the consequences of technology than girls, and that pupils with a higher level of education are more aware of the consequences and importance of technology for daily life.

At the moment research is done in the Netherlands among 11-year old pupils in primary education, and among 16-17-year old pupils in secondary general and vocational education.

Because in many countries attention is paid to the topic 'technology in education', it was evident that internationally there was a great deal of interest in our research. That is why the *PATT-research* was started on our initiative (PATT=Pupils' Attitude Towards Technology). After pilot-studies in 11 countries, which were discussed at the first PATT-workshop in March '86 in Eindhoven, a questionnaire was developed that could be used internationally. The questionnaire consists of the scales that we mentioned before.

With this questionnaire research is done in various countries, among others: Australia, Belgium, Canada, France, Hungary, India, Ireland, Italy, Kenya, Nigeria, Poland, Spain and the UK. At the second international PATT-workshop, in April '87 in Eindhoven, various participants will report their results (Raat et al. 1987).

2. The Concept 'Technology'

We found that pupils have a distorted concept of technology. But what is a correct concept of technology? What concept of 'technology' do we want to convey to the pupils in education?
We carried out a literature study and consulted experts orally to find out what the general characteristics of technology are.
We found the following five characteristics (a broader description is given in De Vries 1987).

1. technology is an inseparable human feature.
   This implies that:
   a. our view of technology is determined by our view of mankind (ideology or religion),
   b. technology belongs to both men and women,
   c. technology, as man himself, has gone through a historical development,
2. technology is always related to changes in the form and/or place of matter, energy and information (the dimensions of technology),
3. there is a mutual influence between science and technology, both with respect to knowledge and methodology,
4. technical skills are: designing, making things, using technical products,
5. there is a mutual influence between society and technology.

At the first PATT-workshop it was decided to take these characteristics as a starting-point for the concept-measures among pupils (Raat and De Vries 1986). Thereby we combined the characteristics 1 and 5 to one scale.

3. Courses about technology

We incorporated the aforementioned characteristics of technology in example-courses (we do not intend to develop a complete curriculum). Because in the Netherlands technology as a separate subject has not yet been introduced, we had to link up with an existing subject. We opted for the subject physics. Physics and Technology are interrelated. It is a good thing for the subject physics if attention is paid to technology. This makes the relevance of the subject all the clearer to the pupils. One has to take care, though, that pupils do not regard technoloy as applied physics. From an investigation we did among teachers of physics it became evident that teachers have this tendency (Van den Bergh in Raat and De Vries 1986). Therefore we organized in-service-training meetings for teachers who wanted to use the courses.

In the courses special attention is paid to designing in technology and to the role of technology in the quality of life. We only use situations from the pupils' daily life.
The themes that have been developed so far are entitled: Making musical instruments, Electrical equipment at home, Communication, Water at home, Do-it-yourself, Nuclear Engineering and Lighting. Of each course an English version is available and also of the teachers' guides that belong to them. The first four themes are meant for pupils of about 13-15 year old, the last three themes are for pupils aged 15-18. An English version of a new theme: Medical Engineering, will be available soon.
In the text and the illustration attention has been paid to the attractivity for girls. From our attitude research it became evident that the girls' concept and attitude is less positive that the boys'.
In every course there are two chapters that deal with technical *objects from the pupils' daily life*, e.g. a guitar or a flute, a coffee maker, an iron, a telephone, a geyser, a tap, lamps, tools. The pupils see how there objects have been designed, how they work and they also learn how to handle them and to do simple repairs. There is also a separate chapter in which the pupils do some *reflections on the role of technology for the quality of life*: how to use electrical appliances in an economic way, how tele-communication has changed society, the good and the bad consequences of it, the influence of technology on jobs in industry.
In the evaluation of the courses we are mainly concerned with the questions:

-> do pupils like to learn something about technology (general characteristics and examples from daily life) this way,
-> what did the pupils learn from the courses,
-> is there a measurable effect on the pupils' concept of and attitude towards technology and the role of technology for the quality of life?

In the evaluation it is important to bear in mind that one measures not only the effect of the courses, but of the course plus the way they were used in class.

While trying to find an answer to the questions above, we pay special attention to differences between girls and boys.
For the evaluation we use questionnaires for pupils and teachers, observations (see PWL 03, November 1986) and tests. The evaluation-research is done among about 2,000 pupils in secondary general education (ages 13-18). At the Symposium preliminary results will be presented in a supplementary paper.
The courses are about the features of technology. Therefore this evaluation can contribute to the discussion about the subject technology in education.
The courses are also relavant for education on the role of technology for the quality of life and for the education on everyday life technology.

4. Technology, a new subject in education

The impact of technology on modern society is still growing. Therefore many people recognize that technology should be a separate subject in education. In some countries it already is a separate subject, in other countries one is introducing it or deciding to introduce it. We think this is a good and an important decision. But we should be well aware of the fact that technology is a subject that has no tradition. That means that the situation is completely different from physics or any other school subject that has a certain tradition. It is not surprising , that in all countries, both the countries that have, and the countries that have not yet a subject technology, the discussion about the aims, the contents and the structure of this subject is still going on (see chapter 3 in Raat et al. 1987).
We hope that our research can give a contribution to the discussion.

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Additional information

In the Netherlands primary education is for pupils aged 4-12 years (grades 1-8); after primary education about two third of the pupils go to secondary general education and one third of the pupils go to vocational education. Secondary general education is subdivided in three types of schools, among them pre-university education, which lasts for six years (grades 1-6). It ends with school examinations and a national written examination (seven subjects).
Our paper is concerned with all three types of secondary general education, both the lower part (grades 1-3) and the upper part (grades 4-6).

Authors

Drs. Falco de Klerk Wolters studied social geography at the State University in Utrecht. He was policy co-worker in the city of Zeist for 1 year and is now working as a researcher at the Eindhoven University of Technology.
He published several contributions to the PATT-1 workshop (Eindhoven 1986), the conference Women Challenge Technology (Elsinore 1986) and the GASAT-4 conference (Michigan 1987).
Drs. Marc de Vries studied physics at the Free University in Amsterdam. He was a physics teacher in secondary general education and in a teacher training college. Now he is working at the Eindhoven University of Technology as the project leader of the project Physics and Technology.
He was co-editor of the PATT-1 report 'What do girls and boys think of technology?, published a report 'What is technology?' and edited the courses of the Physics and Technology project.
Both authors are co-editors of the PATT-Newsletters.

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RESEARCH-ORIENTED POSTGRADUATE SCIENCE AND TECHNOLOGY EDUCATION IN DEVELOPING COUNTRIES WITH SPECIAL REFERENCE TO AFRICA

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INTRODUCTION

Until relatively recently, Africa was a dark spot on the world map. Indeed, it was, for many years, referred to as the Dark Continent. Actually, Africa as a whole, in terms of sunshine hours per unit continent, is, perhaps, the best lit of all the continents. Thus, when talking about "darkness" in Africa, we are largely referring to its relative backwardness in terms of science and technology education. But even there, one has to avoid over-generalisations, particularly taking into consideration the fact that the science and technology that the Egyptians used in building the grand pyramids of Giza, one of the ancient seven wonders of the world, and in mummifying the bodies of the deceased, is still a miracle to modern scientists and technologists.

It should be realised that Africa is a vast continent, and with great contrasts. Socio-economically and sociologically, the northern parts have much in common with Asia. The southern part, on the other hand, in terms of scientific and technological advancement (besides the current socio-political problems), has much in common with Europe. In this paper, the thrust of the discussions will centre on Africa north of the Republic of South Africa, and South of the Sahara.

Africa has also, many times, been referred to as "a sleeping giant". Taking into consideration her vast natural resources, some of which, particularly the mineral- and the aquatic resources, are still awaiting exploration and exploitation, the statement above is, to a large extent, quite true. But of late, things have changed. The giant is, not only waking up, she is getting up.

In this paper, an analysis of the state of the art on science and technology education in Africa, as a case study representing the developing world, is being made. On the basis of what is presented, a number of suggestions and recommendations have been made, and it is hoped that these will stimulate discussion, and that relevant national and international bodies, will consider them favourably.

METHODS

The various ideas expressed in this paper are based on the author's experience as a teacher, and as a researcher; on his travel experience to many countries in Asia and Africa while serving as a consultant to the Food and Agricultural Organisation (FAO), the United Nations Educational, Scientific and Cultural Organisation, UNESCO (Mshigeni, 1985), to the International Development Research Centre, IDRC of Canada (Mshigeni, 1986), on ideas which stemmed from his participation in several international conferences on education and training in Africa (e.g., see Schlette and Schmeling, 1985); and on readings from the literature pertaining to science and technology education in Africa.

THE STATE OF THE ART ON SCIENCE AND TECHNOLOGY EDUCATION IN AFRICA

In all human societies, Africa included, exposure to science and technology education begins at very early age, indeed from childhood days. It is true that the remote villages in Africa do not use telephones, electricity, or modern means of transport. In fact, even to-day, in the very interior of Asia, Africa and Latin America, some villagers will not have seen an electric bulb, a telephone receiver, or even a motor car. Yet, when you carefully and patiently examine what they do everyday, you get overwhelmed over the numerous applications of science and technology education, which dominate their everyday lives.

Let us look at the village hunter, for example. His spear, his arrow-head, his knife, his everyday tools..., were not imported from Europe or North America: they were manufactured by a local technologist. The poisoning on his arrow-heads, is also the product of a local technologist. The traditional hunter, furthermore, will not be bothered if there is no match box around: the technology of making a fire, involving the application of the basic laws of physics (friction), is part and parcel of his basic education.

Take the traditional herbalists. Most of them know what plants can be used as medicine against what human disease, or against what disease in what domesticated animal, or against the diseases affecting what crop plants. They can also tell you what part of a particular plant should be applied in each case.

We often term the yillage farmer's hoe primitive. But actually, if you analyse the nature of his environment, sometimes steep slopes, with many rock-boulders, you will, in many cases, come to a conclusion that the technologies he is employing are most appropriate for the conditions prevailing in his local environment.

In Sukumaland, Tanzania (and in several other districts), the villagers are not scared of snake bites: even bites from some of the most venomous snakes. What they do to the snake-bitten victim is simple: they make a small incision on the wounded part, then they take a special type of stone and fix it onto the wound, followed by bandaging the stone onto the body so it does not fall off..., and that is it. The stone attracts and absorbs the snake venom, thus pulling it away from blood circulation.

Recently, when I returned to my home village, at Mamba, Pare, Tanzania, to see my parents, I met an old primary school class-mate whom I had not seen for many years. In the course of our discussion, I asked him how many children he had, and how old they were. When I learnt that his children were all born three years apart, I got rather curious to know how this had happened, since there are no family planning clinics in the village. Later on, I came to learn that there is plant, which grows as a vine, and which has a root tuber with interesting properties. The villagers take the tuber, dry it in the sun, and subsequently grind it into a powder. "If your wife does not want to conceive, she adds a bit of the powder to her coffee or tea, and drinks it", he said. As long as she does that regularly, she will never conceive, so I was told. If she wants to have another baby, she simply quits drinking the concoction!

The few examples that I have cited above indicate that there are many practices of science and technology education in Africa, which have not been documented as yet, and which could be researched upon through research-oriented postgraduate training. It is a pity that many such traditional technologies are disappearing with the death of our grandfathers.

We need to make a record of the various technologies in various ethnic groups in Africa, and to describe the technologies in detail. To do so effectively we must visit the villagers, and stay with them for an adequate period of time. With a keen eye, with a keen ear, with an enquiry mind, and with a quick pen, we could gather a lot of intriguing information about the applications of science and technology education in Africa. We could even achieve more, if the visits were made through team work, involving sociologists, ethnobotanists, psychologists, etc.

From the field observations and from the field notes, we could then make broad-based hypotheses on possible explanations to the observed phenomena. The extract from the root of the vine that seems to play the role of the contraceptive pill, could, for example, be hypothesized to contain chemical substances similar to those in the pill. But things should not stop there. Scientific experiments should be conducted, to do chemical extractions from the plants, and subsequently, to test them clinically, using appropriate laboratory animals. Thus the follow-up work should be done, following the scientific methods of enquiry.

Unfortuanately, however, many the teachers in our schools are not research-oriented. This is partly because of the poor research infrastructure in their laboratories, poor library facilities, and paucity of funds for undertaking research. But, most significantly, most of our school teachers are not research oriented in their teaching approaches because they lack adequate training on research.

In most of our Universities in Africa, research training begins at Bachelor's degree level. Unfortunately, however, this is given relatively little weight in the curriculum. Research skills are acquired, not by lecturing, or by reading what other people have done, but by practical participation in research. Therefore, even at undergraduate level the students should be given an opportunity to undertake research projects as part of their first degree training.

At postgraduate level, most of our African Universities require most of the candidates enrolled in the various degree programmes to undertake some piece of research, and to write a thesis or a dissertation in the end. But in some cases the candidates are not exposed to adequate research tools: and in a few cases, it is still possible for one to acquire a postgraduate degree qualification by course-work examinations alone. Most Universities in Africa have, however, now realised the significance of research in postgraduate training, and have strengthened the research component of their programmes.

Research-oriented education can be promoted in the secondary schools as well, if the secondary school teachers themselves are research-oriented. It is important, therefore, that our teachers in the schools, particularly those teaching the higher Forms, be given opportunities to undertake postgraduate training. Secondary school teachers who undertake research do, in fact, stimulate their pupils to have enquiry minds. My own experience testifies this. Through the inspiration of my Biology teacher, while in Secondary School, I was stimulated to undertake a research project on breeding behaviour of a polygamous bird, whose findings I subsequently published in the Tanzanian Educational Journal.

Many times, however, at least in Tanzania, many secondary school teachers, who apply to enrol for postgraduate training programmes at the University of Dar es Salaam, fail to undertake the proposed studies due to sponsorship problems, since the

Ministry of Education allocates relatively few scholarships every year for postgraduate training. Special considerations should be made to give more school teachers a chance to undertake such training. Special considerations should also be made to improve the school laboratories, as this will enable the research-oriented teachers to performa better in their teaching, and to build enquiry minds on the part of their pupils. Various donor agencies should also consider giving assistance to the developing countries which propose definite projects on the improvement of science and technology education among Third World Countries.

Many Universities in Africa do, in fact, now have many lecturers and Professors, who have solid training experience in scientific and technological fields, who can effectively train science and technology education teachers for the schools. At the University of Dar es Salaam alone, there are, for example, well over 200 academic members of staff who have the Ph.D. degree qualification. There are almost twice as many Faculty members with the Master's degree qualification, and who, therefore, also have some exposure to research-oriented education.

With the current rate of human resource development in Africa, there is every reason to believe that science and technology education in Africa has a promising future. And it would have a brighter future if adequate inputs, which will lead to the improvement of the current research infrastructures, are provided.

ACKNOWLEDGEMENTS

I am very grateful to Dr. Kurt Riquarts who made special efforts to ensure that I participate at the symposium; to the University of Dar es Salaam for having allowed me to attend the symposium; to Mrs Janet Semhina who kindly and ably typed the manuscript; and to my wife, Grace, for her unlimitted patience and co-operation throughout the writing phase.

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A. INFORMATION ABOUT THE EDUCATIONAL SYSTEM IN TANZANIA

THE EDUCATIONAL SYSTEM IN TANZANIA: PRE-UNIVERSITY

1. Lower Primary School: 4 years: Ages 7 - 10;
2. Upper Primary School: 3 years: Ages 11 - 13;
3. School Certificate: 4 years: Ages 14 - 17;
4. Higher School Certificate: 2 years: Ages 18-19.

MODES OF ASSESSMENT:

1. Lower Primary School:
   - Continuous assessment through tests:
   - Final examination on completion of Grade IV.

2. Upper Primary School:
   - Continous assessment through tests;
   - Final, Primary School Leaving Examination on completion of Grade VII
3. National School Certificate Course
   - Continuous assessment through tests:
   - National Examination at the end of Form II;
   - National School Certificate Examination at the end of Form IV.
4. National Higher School Certificate
   - Continuous assessment through tests:
   - National Higher School Certificate at the end of Form VI.
5. Selection for University Entrance:
   - Candidates who have passed the Mature Age Entry, University Examination:
   - High quality passes of at least wo two Principal Level subjects in Form VI, at same sitting
6. Duration of first degree courses at the University of Dar es Salaam:
   - Three to five years, depending on field of specialisation

B. THE WHERE THE PAPER FITS:

- Technology education

C. ABOUT THE AUTHOR

- Prof.Dr. Keto E. Mshigeni is a Professor of Botany and Director of Postgraduate Studies at the University of Dar es Salaam. He received his B.Sc. degree at the University of East Africa, Dar es Salaam University College, Tanzania, and his subjects of specialisation were Botany, Geography, and Education. Subsequently he went to undertake graduate studies at the University of Hawaii, Honolulu, where he completed a Ph.D. degree programme in Phycology (Marine Botany). Since 1980 he has been serving as Director of Postgraduate Studies at the University of Dar es Salaam, and is in charge of the University's Graduate Studies Programmes, International Co-operation Link Programmes, and Staff Development Programmes. He has also served as a Consultant to several International and National Agencies, and has also published over 70 scholarly papers in fields of Botany and Education. He is wide travelled, and has attended many international conferences and symposia.

TECHNOLOGY EDUCATION AT THE OPEN UNIVERSITY OF THE UK

J.J. Sparkes (Open University, Milton Keynes, Great Britain)

1. The Open University

The Open University is a distance teaching institutions with only research students on the campus. It is designed for adult students whose minimum age is 21 years. It began with the appointment of a Vice-Chancellor at the beginning of 1969. At the present time, the university has rather more than 65,000 undergraduates whose average age is about 27 years. About 70,000 have graduated, 10,000 with honours.

The university offers modular degrees. A student who successfully completes a course obtains a credit or half credit (depending on the amount of work in the course). To obtain an ordinary degree a student must have obtained six credits (or its equivalent, with some credits obtained as two half credits). To obtain a degree with honours, a student must have obtained eight credits, two of which must have been at honours-degree standard. These honours courses are referred to as 3rd-level or 4th-level courses.

The courses that students take on entry are called foundation courses, and are introductory to university work in both content and character and in method of study. The courses appropriate to ordinary degrees are called 2nd-level courses. The courses are named according to level rather then according to year because students are allowed to take courses at their own pace - within limits.

A full credit comprises 32 units of work, each intended to occupy a student for about 10-12 hours, and is regarded as a week's work. Half-credit courses are taken at half the pace, each unit being spread over a fortnight.

One unit is about 12 hours' work comprising:

always	a correspondence text
often	a TV programme (with notes) a radio programme computer-marked assignments tutor-marked assignments
sometimes	home-kit work attending tutorial (sometimes by teleconferencing) using computer terminal audio vision or radio vision self-help groups counselling video tape reading a set piece

Every course finishes with a final examination and about half the courses offered include a one-week summer school at a normal university.

Since Open University students are to be found all over the UK and many are in full-time jobs (including being a housewife and mother), it is rarely possible to give them regular, personal, face-to-face tuition. So each course has to be designed to match its particular educational aims. If mental skills, such as using mathematics, writing or programming are important aims, opportunities for practice have to be provided. If knowledge is the aim the most appropriate medium to convey the information is used - print for data, TV for visual information, audio tapes for authoritative views etc.

But if the understanding of complex and abstract concepts, which is the distinguishing feature of higher education, is the aim, the multimedia methods indicated in Table 1 are generally needed to help remote students to learn effectively.

Grasping concepts is a quite different learning activity from memorising facts etc or from acquiring intellectual skills such as analysis, writing, doing mathematics or creativity.

Since the main educational medium is the correspondence text, and since students in the Open University system cannot immediately ask questions of an author if they have difficulty, it is clear that these texts must be written with great care and must include as much student activity as possible.

2. The Teaching of Technology

There are six Faculties at the Open University, Arts, Social Science, Education, Mathematics, Science and Technology. The Faculty of Technology is divided into five disciplines, Design, Systems, Materials, Engineering Mechanics and Electronics. No discipline offers sufficient courses to enable students to concentrate wholly on one area, so even the most specialist degree profile must include a course or two from another discipline or from another faculty.

The Design and Systems Disciplines are less specialized than the other three, the former being concerned with the principles of Design as a key activity in technology, and the latter being concerned with the complexity of modern organizations, especially industrial ones, and how to analyse the problems of managing them effectively.

The Technology Faculty as a whole has chosen to introduce the study of technology in its foundation course through the investigation of technological issues, rather than by first laying a thorough grounding in mathematics and physics. This is sometimes called the 'top-down' approach rather than the 'bottom up' approach. The philosophy behind this approach accepts, firstly, that technology cannot nowadays proceed without at the same time considering its effect on people, on society and in the environment, and, secondly, that it is essential that this broad view of technology be introduced early in a degree course, in order to ensure that the subsequent, more academic and analytical studies can always be put in the context of their effects and consequences.

In the second and third levels the various technological topics are dealt with separately, or in some instances by two or more disciplines working together, giving, such courses as control engineering and electronic materials and devices. There are basic courses in mathematics and the sciences for those who need them, but much of the development of these subjects is included as required in the technology courses. Whenever possible subjects are taught in the context of design. This means for example, that the mathematical analysis of problems, is extended to include the modelling which enables them to be applied to real design tasks.

For a final honours degree credit, especially for those seeking professional recognition, there is the possibility of carrying out a project comprising an investigation into some technological problem coupled to a proposed solution, properly designed, costed and planned.

Practical work has also to be designed effectively. By being quite clear about the aims of practical activities a good deal of routine laboratory work, that often occupies students time unprofitably, can be eliminated. In general it is not necessary to confirm experimentally results that students have already fully understood. The required practical work tries to set only surprising phenomena and then expects students to apply their newly acquired understanding to the solution to design problems. Demonstrations of experiments or expensive apparatus can be presented in video tapes or TV often more successfully than by showing the real thing.

With both the academic and the practical aspects of technology dealt with in a satisfactory manner it is possible for students to obtain exemption from the Part 11 Engineering Council examinations in certain subjects, and so obtain the status of Chartered Engineer.

The Educational System in the UK

Education in the UK is compulsory between the ages of 5 and 16. About 15% continue at school until they are 18 years old in order to take A-level (advanced level) exams. Selection for university entrance is based mainly on A-level results. A minimum of two A-level passes is required, though most universities insist on three A-levels, with better than minimum pass marks in all subjects. It is possible for 'mature students' (eg over 21 years old) to gain entry based on work experience, though few do so.

The Open University's place in the Educational system

The Open University sets no entry standards other than a minimum age of 21,though even this limitation is about to be removed. Students are selected on a first-come-first-served basis. About 50,000 apply each year but only about 25 000 new students can be accepted each year. Students are advised about their suitability, and other courses are often recommended, but none is preveneted from registering. A good deal of counselling is provided during the foundation year.

Autobiographical note on J J Sparkes, BSc, PhD, FEng

J J Sparkes is Professor of Electronics Design and Communications at the Open University. For 10 years he was also Dean of the Faculty of Technology and for 2 years he was Pro-Vice-Chancellor in charge of Academic policy. Prior to joining the Open University in 1970 he had been Reader in Electronics at Essex University for 3 years and Senior Lecturer in Communications at Imperial College, London for 5 years. From 1952 to 1962 he was in the telecommunications industry, mostly in the Plessey Company.

He has written 3 books on transistors and their applications and has published many papers on aspects of electronics, on educational methods and on the philosophy of science.

ESTABLISHING A LINKAGE MECHANISM FOR TECHNOLOGY TRANSFER BETWEEN NATIONAL SCIENCE AND TECHNOLOGY AUTHORITY (NSTA)- SCIENCE PROMOTION INSTITUTE (SPI) AND THE MINISTRY OF EDUCATION, CULTURE AND SPORTS (MECS) SCHOOLS

Dr. Adoracion D. Ambrosio
(Director, Philippine Science High School)

Objectives:

A. General Objectives:

1. To accelerate the transfer of technologies from the laboratories of the R & D institutes of the NSTA to the end-users, through a mechanism which would link more closely the efforts of the R & D agencies of NSTA and the MECS Schools.

B. Specific Objectives:

1. To transfer the skills and knowledge on specific matured technologies to a selected group of school teachers who are expected to re-echo the training to their students and to their community.

Project Design:

1. A study of the state of the art in the specific areas of concern, as follows:

    a. the school curriculum and what if offers for teaching the scientific processes involved in the transfer of technologies

    b. the existing resources of schools for laboratories and equipment for the teaching technologies

    c. the present capabilities of R & D institutes in terms of expert-trainees and equipment for the transfer of technologies

    d. the present program focus on NSTA regional offices re- the program for technology transfer

    e. the present program thrust of NSTA Proper and the Councils re- the program for technology transfer

    f. related programs of other government agencies re- technology transfer such as those of the U. P. School of Small Scale Industries, the Bureau of Small Scale Industries and the MECS "Sariling Sikap" Program.

2. The creation of committees which would represent the decision makers, the technical advisers, and experts from both the NSTA and MECS at the national as well as regional level.
3. The conduct of training programs on the transfer of the technologies.
4. The installation of a monitoring and feedback mechanism to evaluate the impact of the training programs on technology transfer.
5. Overall assessment of project accomplishments.

Organization of the Project

To establish the linkage mechanism for the technology transfer project, the following bodies were constituted with representatives from both cooperating agencies the National Science and Technology Authority (NSTA) and the Ministry of Education, Culture and Sports (MECS). These bodies were charged with specific functions involved in planning, monitoring and evaluation of the project activities. They are as follows: A project team, a technical panel and an advisory committee.

A Project Team composed of a project director, project coordinator, project leader, statistician and special disbursing officer was designated from the officers and staff of the Science Promotion Institute (SPI) and the National Science and Technology Authority (NSTA).

Functions of the Project Team:

1. Set project objectives
2. Decide on plan of action
3. Develop strategies
4. Identify and analyze various job tasks to implement the project
5. Determine the allocation of resources including budget, manpower and facilities
6. Assign specific job tasks and responsibilities
7. Coordinate on-going activities
8. Measure progress toward and deviation from Projects' goal
9. Takes corrective action of project plan

Functions of the Technical Panel:

1. Prepares the training design
2. Acts as trainors/resource person
3. Evaluate outcome of training
4. Evaluate feasibility of the linkage mechanism

Functions of the Advisory Committee:

1. Establish the Terms of Reference (TOR) for the cooperative project. The TOR defines: 1) objectives, 2) strategies, 3) plan of work, 4) resource requirements, 5) expected output, 6) commitments of the cooperators.

2. Reviews the outcome of the initial implementation of the plan on establishing the linkage mechanism, for technology transfer between NSTA-SPI and MECS schools and makes recommendation for a plan of expansion.

Planning the Training Programs

In planning the training programs to be undertaken for the transfer of technology, in this case the transfer of R & D technologies from the NSTA institutes; the Technical Panel took into consideration the following factors:

a. product specialization
b. different indigenous resources
c. values of the populace
d. level of awareness
e. level of absorption
f. delivery system

The products and processes in which the R & D institutes have specialized were identified. Thus, the Forest Product Research and Development Institute(FORPRIDI)atLos Banos was tapped for the technology on charcoal briquetting and charcoal production; and the National Institute for Science and Technology (NIST) for the processing of coco-based product and fruits. Guided by information from the NSTA Regional Coordinator, Region IV regarding indigenous resources, the products which are found to be more or less in abundance in the region were tapped. Identified are the fruits and vegetables in season, coco-by products; and the sources of charcoal dust.

Identified also are matured technologies which are ready for delivery from the R & D institutes. These are in line with research and development activities of the NSTA institute, which focuses on the processing of coco-by products, the production of charcoal and the technology of charcoal briquetting, and fruit preservation.

Availability of manpower expertise for the training programs was a consideration in the scheduling of the training program; likewise the choice of a venue accessible to the majority of participants.

For the three training programs the most appropriate venues selected are the schools (DSAC and SPSAT Training Center) and the NSTA-KKK CGL Demonstration and Training Center, Lucena City.

The two other factors, values of the populace and level of awareness were perceived as supportive of the transfer of technology program.

For this project, no systematic study of the level of absorption of the region of the processed product was made. However, contacts with the University of the Philippines Institute of Small Scale Industries revealed that such information can be obtained.

Project Implementation

Directed towards the accomplishment of the principal project objectives, which is to establish a linkage mechanism between the MECS schools and the NSTA with the Science Promotion Institute (SPI)as the focal point for the transfer of the matured technologies from the

NSTA R & D institutes to the teachers and students of both the formal and non-formal school system, the planned linkage mechanism was initially implemented in Region IV.

The major activity of the Project is the holding of training/seminar workshops on the transfer of the identified technologies from two R & D institutes, the FORPRIDI and the NIST. Namely: 1) charcoal production and charcoal briquetting; 2) processing of coco-by products, including coco-jam vinegar making, soap making; 3) fruit processing, i.e. candy making.

The participants of the training program are the public elementary school teachers (Home Economics and non-formal) of Indang, Cavite, the public high school teachers of Quezon National High School, Lucena City; other school teachers Division of City Schools, Lucena City and the teachers of vocational and trade arts of the San Pablo School of Arts and Trades, Laguna.

Constraints in Project Implementation

1. Changes in top level officials of the cooperating ministries: The Project was launched at the time Minister O. D. Corpuz of MECS resigned and for some time the MECS was at a stand still.

   After having made initial feelers with the top officials of the Bureau of Elementary Education, Bureau of Seocndary Education, the Office of Non-Formal Education and the MECS Region IV, this project director changed plans about coming to an agreement at the Ministry level instead commitments for cooperation at the regional/bureau levels were reached.

2. Changes in program priorities at the NSTA: A top priority project of the NSTA Minister is the NSTA-KKK project for the transfer of matured technologies from the R & D institutes. However, with the budget cuts for 1984, the Budget Ministry had indicated that funds for activities concerning livelihood projects should be sourced from the KKK Livelihood Program.

   The NSTA was therefore constrained to give lowest priority for funding to the NSTA-KKK project. This change in thrust temporarily affected the assignment of scientists-technologists as resource persons for the training programs for the transfer of technologies from the R & D.

   a. Politics and the 1984 Elections

      The period for holding the training program at Indang, Cavite coincided with the election ban which constrained program organizers who opted for the involvement of local government officials such as the Mayor of Indang. Thus, the training program was postponed to after the election period.

   b. Teacher Participation and the School Calendar

      Inasmuch as the Project was conceived more than half way of the school calendar; there was the time element to consider. The school activities had been planned at the beginning of the school year and the teachers could not participate in the training program until after the end of the school year. This meant further that only teachers who were rendering service during the summer term were available for the training program.

c. Assignment of Resource Persons from the R & D Institutes

The training programs could only take place when resource persons from the R & D institutes are available; thus it is important that R & D institutes support the Project.

Project Accomplishments

This project has demonstrated the feasibility of establishing a linkage mechanism between NSTA and MECS for the transfer of matured technologies from the research and development (R & D) institutes to teachers and students through the schools utilizing primarily the training program. Identified as the focal point in the linkage mechanism is the Science Promotion Institute, the promotional arm of the NSTA, to orchestrate the efforts for technology transfer between NSTA and the collaborating Ministries.

The linkage mechanism is a operationalized in the creation of an Advisory Committee, a Technical Panel and a Project Team with membership from both ministries.

Essential to the successful operation of the linkage mechanism is the designation of officials/persons from both ministries who could bring their expertise and leadership as well as commitment to the cooperative undertaking.

Through their representatives sitting in the three bodies, both cooperating ministries, MECS and NSTA-SPI participate in the planning, monitoring and evaluation of the projects.

Figure A illustrates the writers conceptualization of the linkage mechanism spanning the cooperative effort through three stages: planning, monitoring and evaluation. It illustrates the hierarchy of functions, as well as the scope of responsibility of the mechanism for cooperation vested in three bodies: The Advisory Committee, the Technical Panel and the Project Team. Figure A also illustrates how the inputs of the three groups of advisers, experts, project developers and evaluators goes to the targeted clientele using the channel of the training programs and how the clientele feedback in turn reaches the hob of the linkage mechanism.

The present set up for the technology transfer effort of the R & D institutes linked directly to the schools is illustrated in Figure B.

The project work flow is conceptualized in Figure C. The flow chart of activities demonstrates the sharing of resources and capabilities, and the specific role of each of the cooperators. It is shown

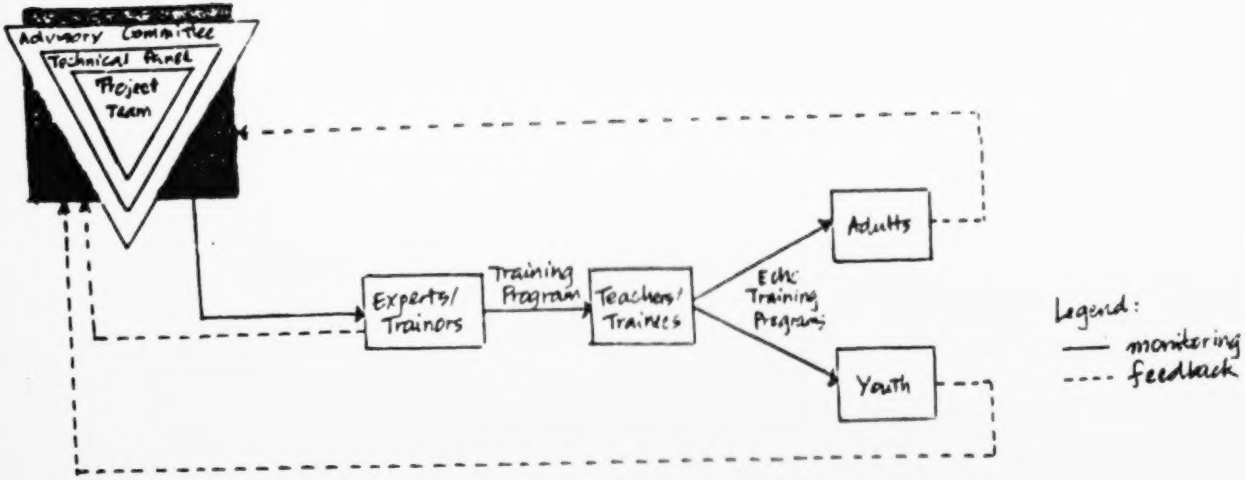

Advisory Committee
Technical Panel
Project Team
Experts/ Trainors
Training Program
Teachers/ Trainees
Echo Training Programs
Adults
Youth
Legend:
monitoring
feedback

Figure A : NSTA - MECS Linkage Mechanism for Technology Transfer

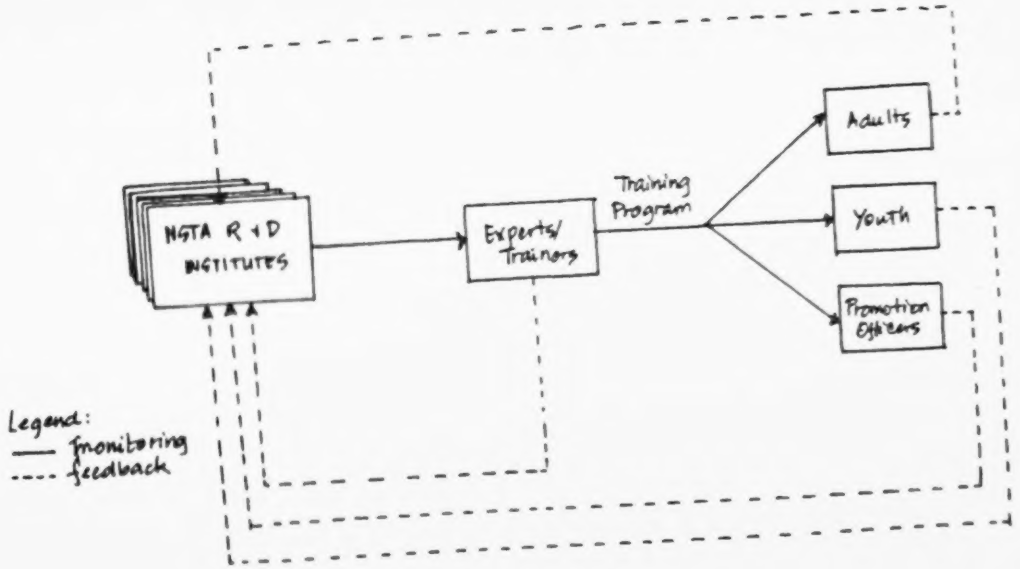
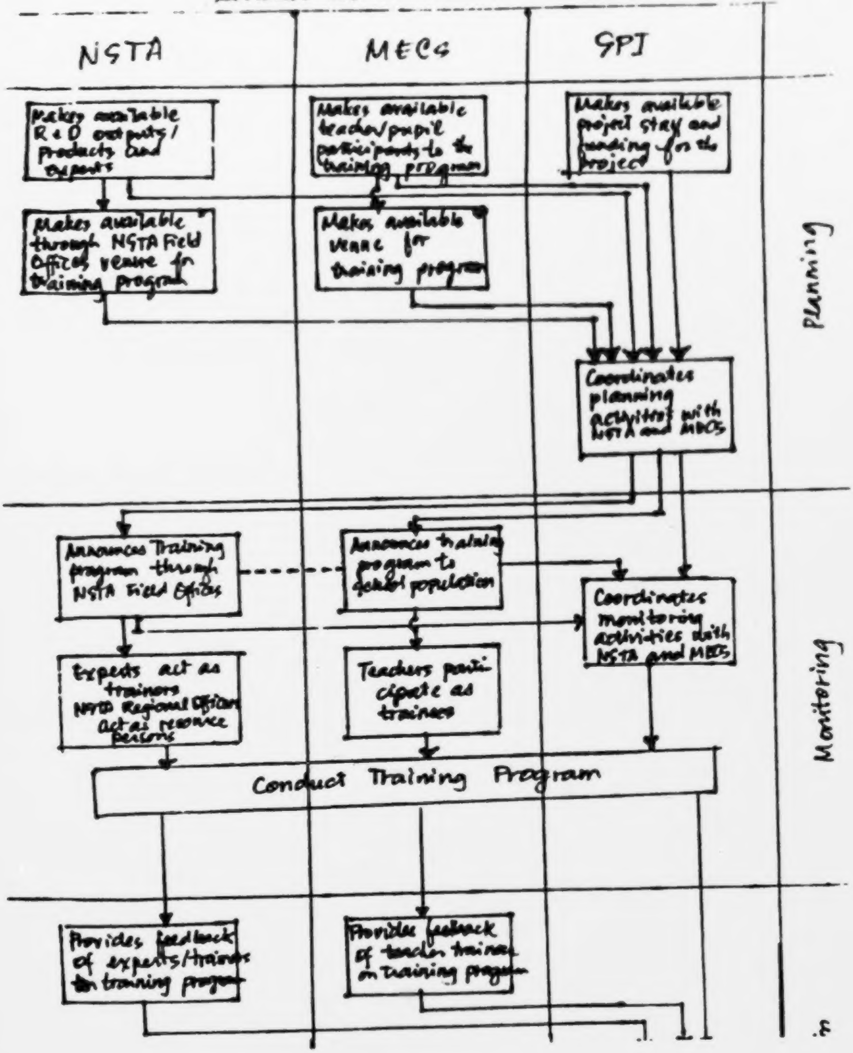

NSTA R & D INSTITUTES
Experts/ Trainers
Training Program
Adults
Youth
Promotion Officers
Legend:
—— monitoring
- - - - feedback

Figure 8 : NSTA R&D Institutes Technology Transfer Mechanism

PROJECT WORK FLOW

Establishing a Linkage Mechanism for Technology Transfer Between the NSTA and the MECS' Schools


NSTA
MECS
SPI
Makes available R & D outputs/products and experts
Makes available teacher/pupil participants to the training program
Makes available project staff and funding for the project
Makes available through NSTA Field Offices venue for training program
Makes available venue for training program
Coordinates planning activities with NSTA and MECS
Planning
Announces Training program through NSTA Field Offices
Announces training program to school population
Coordinates monitoring activities with NSTA and MECS
Experts act as trainors
NSTA Regional Offices act as resource persons
Teachers participate as trainees
Conduct Training Program
Monitoring
Provides feedback of experts/trainors on training program
Provides feedback of teacher trainees on training program

that the SPI as focal point is tasked with coordination in all aspect: planning, monitoring and evaluation.

All inputs of the cooperators at each stage of the process of implementation feeds to the training program which is the vehicle to reach the targeted clientele of the project.

Both mechanism have their strong and weak points. However for the purpose of extending the impact of the program of technology transfer, the cooperative mechanism established is expected to be more effective.

The cooperative mechanism promises to be more effective because there is established a channel to seek out the targeted clientele. Furthermore, the mechanism provides a regular channel for the sharing of resources as well as responsibilities for project implementation. Thus, if the schools are made regular partners of the enterprize; they can identify trainees as well as serve as venues for the training. The R & D institutes therefore need only to provide the experts for training. Continuing support for the technology transfer program can also be assured if undertaken as a special project with separate funding preferabldy from the NSTA grants-in-aid.

The mechanism likewise makes possible the continuing involvement of officials of both NSTA and MECS at the national as well as the regional level.

One other output of the project is a monitoring/feedback scheme to follow up the activities of the trainees at least six months after training. This monitoring/feedback mechanism will provide information on the impact of the training program conducted for technology transfer.

Significance/Project Impact:

Considering the millions of pesos spent by the government for research and development (R & D), it is important that the output from the R & D should reach a broader base of the population.

The matured technologies from the laboratories of the R & D institutes are delivered thru workshops, lecture demonstrations and publications describing the technologies through the information units of the R & D institutes or the field offices. At present, these channels for technology transfer at the NSTA have limited capability to reach the end users of the technologies. This maybe attributed partly to the present structure of the R & D institutes and the NSTA field offices and to the constraint on resources for the technology transfer program.

If the situation is not attended to, the matured technologies would not be transferred to the end users; thus, no economic benefits would accrue to the Filipino entrepreneur. Furthermore, indigenous technology in this country would not progress without feedback from the end users to the researchers of the R & D institutes regarding the acceptability of the product/process.

This Project is designed to demonstrate the feasibility of a mechanism which would link the efforts of the NSTA - R & D institutes for the transfer of technologies to a specific sector of the end users, i.e. the teachers, their students, and the community through the channel of the schools.

The sharing of resources, including manpower and facilities is expected to maximize the present capabilities of the cooperating institutions at both the national and regional levels involved in the technology transfer program.

If the project objectives are attained and funds are available; hopefully the policy makers of both NSTA and MECS would extend priority attention to the provision of equipment and training facilities not only at designated training centers but also in identified government schools.

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A. Pre-University Educational System:

For the academic stream in the educational ladder, the pre-university level consists of the elementary (6-7 years) and secondary (4 years). Approximately, elementary school pupils are between the ages of 7-12 years; while secondary school students are between the ages of 12-16 years. For university entrance, graduates of the four year secondary school curriculum (academic or vocational/trade/agricultural high schools) must pass a National College Entrance Examination given by the Ministry of Education, Culture and Sports.

a) The paper herein presented falls at the secondary level of the educational system.

b) Dr. Adoracion D. Ambrosio the writer of the paper, "Establishing a Linkage Mechanism for Technology Transfer between the SPI-NSTA and MEC's Schools", at present is the director of the Philippine Science High School, a residential high school which prepares scholars funded by government for careers in science and technology. Prior to this appointment, Dr. Ambrosio was deputy-director of the Science Promotion Institute (SPI) an institute under the National Science and Technology Authority, the policy making body in science and technology in the Philippines. Dr. Ambrosio's professional career includes teaching stints at the secondary and collegiate level in the private schools and colleges and at the University of the Philippines in her field of specialization. Dr. Ambrosio is holder of the degree of Doctor in Education, major in International Educational Development Studies and Educational Planning from Teachers College, Columbia University, New York City, 1979. She has been the recipient of scholarships and fellowships awards in the pursuit of her studies at the Institute of Educational Planning, Unesco, Paris, at the Institute of Economics, Oxford University, U.K. at the University of California, Berkeley and the Teacher College, Columbia University. She has been involved in the formulation of plans and policies; the monitoring and evaluation of programs and projects in the field of science education and scientific manpower development at the National Science and Technology Authority. Thru such involvement, Dr. Ambrosio has established linkages with agencies, governmental as well as non-governmental in science and technology education both in the national, regional as well as international context. She has represented her country at international conference as expert, among this are: the Consultative Meeting of Expert called by Unesco in Paris, October 1982 on the "Methodology in Data Collection on S & T Education and Training at the Third Level", 29 September-October 1982. Dr. Ambrosio was a Philippine delegate to the Third International Symposium on World Trends in Science & Technology Education, Brisbane, Australia, 7-20 December 1984.

Dr. Ambrosio is a Career Executive official of the Republic of the Philippines.

TEACHING TECHNOLOGY - REFRIGERATION, AN EXAMPLE FROM NEW ZEALAND'S ECONOMIC HISTORY

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INTRODUCTION

Scientific technology does not feature strongly in science or other lessons in New Zealand schools. While many teachers acknowledge the educational possibilities of technological examples, few have the resources or experience to develop them. Instead teachers work from textbooks with a theoretical approach to science topics, which tell them what to teach and how to teach it. If technological ideas are to be incorporated into science lessons, then researchers need to develop, implement, evaluate and refine materials to the standard of least equivalent to conventional textbooks. We have devised materials and methods for teaching science from technology, and have monitored their use. Our approach is based in part on the generative learning model (Osborne and Wittrock 1985), one element of which is the role learners play in the active generation of meaning through the interaction between new sensory inputs and ideas already incorporated (or subsumed) into long term memory. Since we are interested in the matter of attention (which is like the constructivistic notion of engagement), our task is to find ways of holding students' attention for sufficient time for them to become committed to learning the subject matter. One of the teaching strategies developed by our group is based upon students asking successively more penetrating questions about a specific idea or event, while undertaking investigations which might provide insights into, or answers for, some of these questions. In the process they interact with the ideas of their peers, the teacher, and others (Biddulph and Osborne 1984). Eliciting questions depends largely upon the regard the students hold for that topic, both as it is introduced and later as it is developed. Our view is that attention is promoted by using materials chosen for their social or economic significance, particularly if these come from the students' cultural environment (Kelly 1978).

PURPOSES

Our main aim has been to develop science concepts within a technological context. Another aim is the establishment of positive attitudes towards technology. The possibility of displaying technology as an intellectual activity which illustrates the capacity humans have for solving problems about their survival and comfort, and as a determinant of the directions in which our culture has evolved, has not been explored with our students.

CHOOSING TECHNOLOGICAL SYSTEMS

Our views (Cosgrove 1986) have been developed, in part, from those of Black and Harrison (1985), Kelly (1978), and Stead (1982). The latter two have considered specific students who may be disadvantaged in science; all female students, and Polynesian students, respectively. We justify our choice of refrigeration on the grounds of:

Scientific significance. The way we think about heat and its transfer is crucial in understanding many natural and technological systems. Students of physics should confront these ideas.

Educational significance. The mechanical view of heat is not as intuitive as the more common view which gives heat the properties of a substance. To help learners modify their intuitive notions, we would begin by exploring their ideas about heat and heat flow using everyday phenomena.

Historical significance. Since the European settlement of New Zealand about 150 years ago, the economy has developed through a series of technological innovations in the dominant industry, agriculture. The first, and probably the greatest of these was the transport of refrigerated foods to Great Britain, yet very few people understand the science or the technology of refrigeration.

Technological significance. Some household appliances have markedly affected the quality of life particularly in the storage and preparation of food. Students can imagine what life would be like without refrigerators.

CLASSROOM IMPLEMENTATION

In this investigation, three groups totalling 53 students (age 16 years), in the first year of formal physics spent 10 hours of class time over a period of three weeks, with their teacher (M.F.). The classes were attended by an evaluator (B.N.) who up until that time had not been associated with this project. In the following summary of a teaching sequence (Cosgrove and Mueggenburg 1986), the capitalised terms identify the stages.

This topic was INTRODUCED by the teacher using a public television programme about the impact of refrigeration on agriculture and trade. Then the students wrote an INITIAL STATEMENT of their ideas about how a refrigerator operates. Next, the students recorded their 'BEFORE' QUESTIONS, for which they would need answers if they were to make better explanations. The fourth stage was a series of ACTIVITIES, based on other students' questions, exploring specific aspects of refrigeration. These were:

1. viewing a photographic display of domestic and industrial refrigerators
2. dismantling an obsolete refrigerator
3. using thermostats to switch current on or off
4. comparing insulating materials
5. measuring temperatures in an operating refrigerator
6. investigating freon-filled cannisters
7. compressing air using a cycle tyre pump
8. expanding compressed air from a car tyre
9. investigating the evaporation of a volatile liquid.

From the ensuing discussions students recorded their 'AFTER' QUESTIONS, for which they now needed answers if they were to satisfactorily explain the operation of a refrigerator as a heat pump. These questions were the first part of a stage in which each student would prepare a summary or 'AFTER' STATEMENT. In this stage, the students used the staff-education audiovisual materials provided by a refrigeration manufacturer, and then asked a visiting EXPERT to help in developing answers. Next the students designed a refrigerator (using as starting materials a polystyrene box and a can of freon) and developed their explanations for the processes occurring in each component of their design.

EVALUATION

There were 3 parts to this evaluation. The first was a series of informal observations and interviews with a number of students during the course of the unit (not further discussed in this report). The second part was based on the responses of 45 students (28 male) to a free-choice questionnaire. The third was an analysis of students' statements made at the beginning (by 43 students), at the conclusion (by 17 students) and a few weeks later (by 47 students) (Newman 1986).

ANALYSIS OF QUESTIONNAIRE RESPONSES

The practical activities: Two questions dealt with how the students perceived the practical activities. A majority mentioned the freon activity as one of those that they were most interested in, (58%), and as one of those that most helped them to understand how a refrigerator operates, (60%).

The unit overall: Three questions dealt with the unit as a whole, and the sequence it followed. Students were asked to indicate whether or not they were interested in how a refrigerator operates, whether or not they had ideas on how a refrigerator operates, and whether or not they had linked some of these ideas together. A majority indicated that they

(a) were interested in how a refrigerator operates while working with the practical activities, (62%), and when designing their own refrigerator, (67%);

(b) had developed ideas on how a refrigerator operates when working with the practical activities, (80%), when interacting with the class as a whole, (56%), when designing their own refrigerator, (73%), and during a discussion with an expert, (63%);

(c) linked some of these ideas together when working with the practical activities, (69%), when interacting with their peers, (64%), when interacting with the class as a whole, (62%), when designing their own refrigerator, (87%), and in the discussion with an expert, (53%).

Aspects which assumed considerable significance for these students during this unit were the practical activities, designing one's own refrigerator, interaction with fellow students and the discussion with an expert.

Attitudes: Two questions were directed at students' attitudes towards the unit as a whole. 62% claimed they liked the unit either a reasonable amount or a lot, while a further 20% claimed they liked it a little. When asked to compare the approach of the unit in teaching physics with "the usual way physics is taught", 51% claimed they liked this approach better, while 13% claimed the reverse.

Understanding: At the end of the unit, 93% claimed that they thought they had a reasonable understanding, or greater.

ANALYSIS OF STUDENTS'INITIAL AND AFTER STATEMENTS

When asked to make a statement at the beginning of this unit about how they thought a refrigerator operates, 23% claimed that they did not know and made no further statement. The average number of words used by the remaining 77% was 17 (range 2-43). The 17 statements (from 1 of the 3 groups) examined at the end of the teaching sequence contained an average of 60 words (range 30-100). Four weeks later, 47 students made statements about how a refrigerator operates, and these averaged 88 words (range 18-252). It is worth noting that very few students used a particle model to explain aspects of these physical changes, despite the emphasis given to this model in the science curriculum in the previous five years.

GENDER DIFFERENCES

The gender differences which emerged from this study (Table 1) are particularly interesting.

CONCLUSION

We are confident that this approach has been effective in gaining students' attention, as shown by their comments about interest, confidence and understanding, particularly for female students. Some learning has occurred, but not the usual physics knowledge required by official syllabuses. This approach, based upon a theory of learning and a teaching strategy derived from it provides an effective alternative to the conventional textbook-driven approach.

This study (and others undertaken in the Science Education Research Unit) suggest that conventional physics lessons may demand too much of students at too early a stage. The 16-year old students in this study were in their first formal programme of physics. Previous contact with the subject would typically have been brief, unrelated to the everyday world, and taught by teachers with little empathy with physics. Few 16-year old students are confident about their understandings in physics, or of their capacity to interpret theories and apply them to natural and technological phenomena. This approach suggests some gain in confidence.

FURTHER DEVELOPMENTS

Two specific developments are planned. The first is to add an IN-DEPTH stage in which students can investigate the topic further, by selecting a study from

1. exploring the role of refrigeration in horticulture, medicine, animal breeding;
2. using a journalistic approach in which the scientific aspects of refrigeration would be incorporated into a television programme on the impact of this technology;

TABLE 1. QUESTIONNAIRE ANALYSIS - SOME GENDER DIFFERENCES

	Students' Comments	Gender Ratio	
1.	claiming interest in how a refrigerator works before the start	36% male	0% female*
2.	claiming to have ideas on operation before the start	57% male	18% female*
3.	claiming to have ideas on operation after discussing activities	43% male	77% female
4.	claiming to have ideas on operation during audiovisual segment	25% male	65% female*
5.	claiming to put ideas together on how a refrigerator works during the audio-visual show	32% male	65% female
6.	mentioning thermostats as the most interesting activity	36% male	59% female
7.	mentioning dismantling a refrigerator as one activity that was interested in most of all	50% male	17% female
8.	mentioning dismantling a refrigerator as one activity that helped understanding most of all	43% male	6% female*
9.	mentioning freon as one activity that was interested in most of all	50% male	71% female
10.	mentioning freon as one activity that helped understanding most of all	46% male	82% female*
11.	claiming to feel reasonably confident while working on the unit	50% male	35% female
12.	claiming to feel satisfactory while working on the unit	43% male	59% female
13.	claiming to like the approach of the unit better than the usual way of learning physics	46% male	59% female
14.	claiming to like the usual way of learning physics better than the approach of this unit	21% male	0% female
15.	making satisfactory or better after statements	33% male	70% female*
16.	of those making satisfactory or better after statements those using one or more diagrams	80% male	17% female**
		Male	Female
17.	of those making satisfactory or better after statements, the average number of words used	77 words	127 words***

Key
* statistically significant at the 5% level using a χ^2 test with a Yates correction
** statistically significant at the 2% level using a χ^2 test with a Yates correction
*** statistically significant at the 2% level using a Cochran and Cox t test

3. investigating related scientific matters, including latent heat, specific heat capacity, kinetic theory of gases;
4. considering technological topics such as feedback and control systems, earlier refrigerants, the development of the freons, and atmospheric effects of such compounds;
5. studying the social impact of this technology on society.

The second development is **STUDENT-LED TEACHING** of the scientific matters listed in point 3 of the in-depth stage. Thus a three-stage teaching strategy is evolving. The first stage is a set of exploratory activities, as has been described in this report. The second consists of the in-depth studies described above. (These two stages are predominantly technological in orientation.) The third stage is the development of rational explanations for the phenomena involved, and is the scientific stage. Development will be slow. Although teachers have recently been given considerable freedom in developing courses for the sixth form programme (grade 11), they are reluctant to make extensive changes rapidly.

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PRE-UNIVERSITY EDUCATION SYSTEM IN NEW ZEALAND

Year	Age	Stage
1 - 6	5 - 10	primary school
7 - 8	11 - 12	intermediate school
9	13	secondary school
10	14	
11	15	note (a)
12	16	note (b)
13	17	note (c)

Notes

(a) students may leave school at 15 years

(a) students take the School Certificate exam in up to 6 subjects

(b) at the end of year 12, students are awarded a Sixth Form Certificate with grades (moderated on the previous year's results in the School Certificate examination). Some students enter University at this stage, but with specific permission

(c) at the end of year 13 students may be awarded a Higher School Certificate (on a pass or fail basis), and/or they may sit the University Bursary examination, and the University Scholarship examination

The students taking part in this study were in grade 12, called form six. In this year students take five or six courses which can be designed by teachers; each course of study is ratified by the Education Department.

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SCHOOL MATHEMATICS, ADVANCED TECHNOLOGIES, AND RESPONSIBLE CITIZENSHIP

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INTRODUCTION

This paper attempts to synthesize diverse trends and thinking relating to education in an information technology age. It focuses on the place of mathematics in contributing to basic curricular experiences needed for responsible citizenship today and in the coming decades.

TWO AREAS STUDIED BY THE AUTHOR

Since about 1980, the author has focussed his thinking and study on two related areas: (i) the impact of advanced technologies on the school curriculum in mathematics (ii) the re-design of school mathematics curricular experiences as a whole, in the light of i) and the other educational and global needs and trends.

In 1982, he made a research proposal to the Social Sciences and Humanities Research Council of Canada to conduct a broad yet detailed study of enterprises in Canada using high technology in a production, consumption or service mode. As a first step, a feasibility study under the auspices of the Council was designed and carried out in two phases - (1983-84 and 1985-86) with a sabbatical leave intervening in which the author studied developments in school mathematics, science and technology in Australia and the U.K. For the research study (Crawford 1986a) two questionnaire instruments were developed - one based on a classification of mathematical activities and processes, the other based on an 'inclusive' list of basic mathematical topics for schooling for ages 5-16. Both were based on extensive research and development work in the 1970s and 1980s (see for example Bell (1978) and Wheeler (1982). The result was a 2-level process taxonomy. Basic mathematics activities/processes were seen as forming a sequence consisting of classifying, abstracting, representing, transforming, and validating. A second set of five complex and composite processes were identified as proving, problem-solving, modelling, mathematizing and investigating. The basic content/topic list for the other questionnaire was also developed from a number of sources, including Romberg and Montgomery (1976), National Council of Teachers of Mathematics (1980) and the Report of the Cockcroft Committee of Inquiry into School Mathematics in England and Wales (1983).

Some forty employees of a large hi-tech telecommunications plant in Ontario were interviewed using these questionnaires. They represented four levels of responsibility (manager, engineer/technologist, production worker and clerical worker) and spanned the operation of the plant from research and development through design and production to sales, marketing and management. The main findings of the study were:

(i) All employees use activities and processes which parallel those of the process taxonomy in planning and carrying out their work.

(ii) The computer is widely used in all the areas and phases of the enterprise - for accessing and retrieving data, and for monitoring and control purposes.

(iii) "Percentage" is perceived to be a centrally important area of the school mathematics curriculum.

(iv) There was general agreement that school mathematics was too theoretical and unrelated to real life, and should be revised in the direction of applications and everyday users of mathematics.

The implications of (i) seem particularly important for school mathematics. What seems clear is that the set of basic activities and thinking processes which workers at all levels in this technological plant use mirror those used in doing mathematics. The significance of these processes for the curriculum has also been emphasized recently by Romberg (1983). If curriculum development, and the teaching and learning of mathematics can be systematically re-designed to take full advantage of this finding, the meaningfulness of mathematics can be increased many-fold for the overwhelming proportion of students who still find mathematics mystifying, and generally irrelevant for their lives. Linked to the process dimension, however, must be the dimensions of (i) which mathematical content is most appropriate, and (ii) how is this content best learnt by each student. Clearly, the whole classroom and school learning environment or climate is a significant interactive factor in the situation. The author intends to broaden the feasibility study to conduct up to about twenty similar case studies across Canada in a variety of significant areas of economic and social activity (communications, software and artificial intelligence, advanced manufacturing technologies, service industries and enterprises, biotechnology and resources) (Crawford 1986b).

Focus by the author on the re-design of school mathematics began in 1979 with a comparative study of school mathematics assessments in the U.S., the U.K., and Canada to identify areas of curriculum which needed re-thinking and improvement (Crawford, 1980). This led to a research study on the significance and place of estimation and approximation in the curriculum (Crawford 1982), and to the realization that these ideas together with measurement formed a major basis for much of the actual use of mathematics by the typical person in the real world as well as in the realm of industry (accuracy, precision, control and efficiency). The author continued to develop these ideas on sabbatical leave and on his return and has produced a major paper which attempted to synthesize them (Crawford, 1986b).

This on-going attempt to re-design the "core" mathematics curriculum in schools is based on several premises which are strongly supported by recent international thinking in education and mathematics education (Council of Europe 1979, UNESCO 1985, Proc. ICME V, 1986).

1. Mathematics *should be presented mainly as a powerful tool for use in solving problems and in acting responsibly as an individual and citizen.*
2. Ongoing and frequent provision should be made in the curriculum for *interdisciplinary or ultra-disciplinary tasks* involving mathematics and other subject areas.
3. The curriculum should be designed to *foster increasing independence of the student* from the teacher in order to develop initiative and responsibility for self-directed learning.
4. Learning should include *innovative learning which is future oriented and participatory*, as well as 'maintenance' learning.

A model of curriculum in line with these premises has been proposed recently in the U.K. by Black and Harrison (1985) who put forward *A Curriculum of Resources and Tasks* in which individual subject areas act as resources for 'practical' tasks which are interdisciplinary, drawing on subject areas as required. They claim that their model can unite the practical with the vocational, and the academic with the liberal. Theoretical support for the model comes from the work of Piaget and Bruner both of whom claim that knowledge and action must be linked together in a curriculum for it to be acceptable. The concepts of autonomy and integration have also received considerable discussion in the last decade and innovative learning as a necessary approach to prepare individuals and societies to act in concert in new situations has been proposed in one of the Club of Rome Reports (Botkin et al 1979). Innovative learning has two primary and mutually related factors, anticipation (as opposed to adaptation) and participation, which honours the near-universal and consistent demand at all levels in the world for equitable participation in determining societal issues, especially at global levels.

DEVELOPING AND IMPLEMENTING A RE-DESIGNED CURRICULUM

In the author's view, there are many encouraging signs that the mathematics curriculum (and indeed the curriculum as a whole) are becoming less isolated from the real world. The continuing discussions and trends involving the use of the microcomputer (Howson and Kahane, 1986), the move towards integration of science and technology in schools (IOSTE, 3rd Symposium 1984) and a general realization of the need to see the curriculum as a whole (Goodlad, 1987) are all significant. Yet in all of this, few voices are raised about the basic position of mathematics in schools, and the need to integrate it with the rest of curricular experiences. Initial work by the author outlined briefly at the IOSTE Brisbane symposium is continuing, and it is hoped that an inter-disciplinary group representing math, science and technology can obtain funding to begin a development project.

Here, a brief outline will be given of areas of global significance which the author believes, mathematics as a resource, should become an important part of a "resources-tasks" curriculum. Sources used include recent Association for Supervision and Curriculum Development publications by Remy (1979) and Morissett (1982) emphasizing the increasing need for general education for citizenship as a necessary foundation for informal civic participation in an environment of global interdependence, and an exciting new social science curriculum containing a central interest in values with a strong future orientation proposed by McDanield (1974) who uses a cultural systems approach to explore continuity and change in a number of areas such as population, technology, culture and ecology.

As an illustration of interconnecting mathematics and responsible citizenship, let us focus on the responsible use of a basic human and material resource - water - drawing on books by Allen (1982), Peccei (1982), Keating (1986) and Fremont (1979). Fremont provides a useful model by discussing mathematics and the environment - in particular the use and abuse of air, water and energy. His approach is to confront the student with wasteful practices that are individual responsibilities. He uses data from Biehman (1973) to develop awareness of the individual use of water (then 200 litres a day in the USA). Keating supplies 1980 data on annual individual water use in 22 western countries, which shows a range of use going from 2.3 million litres (Ml) in the USA down to 0.2 Ml in Switzerland. Canada uses 1.5 Ml. Canada and the USA share the Great Lakes system which has about one-fifth of all the fresh water on the earth's surface. Pulver (1986), in a review of Keating's book, notes that an individual needs two to five litres a day in water and other liquids and foods to maintain the body's water balance. While Africans use about that amount a day, Canadians use an average of 288 litres. With the advent of the microcomputer, it should now be possible to enter data of this kind, showing trends of use not just of water but of other basic resources such as agriculture, forests and fisheries. The student can then be led to ask questions such as those developed by Fremont:

> Why does the use of water generally continue to increase each year? If domestic users save water will the total amount used fall off sharply? Why?

Finally, Fremont also provides tabular data on the Earth's total water supply (about 4×10^{11} litres), noting that 92% of this is ocean water. The relationships between the use of water and other factors - population, climate, natural water resources, cultural norms can then be studied. Pulver reports:

> While we (Canadians) use water without thinking, half of the world's 4.8 billion people cannot get enough clean water, and one third have inadequate sanitation, a criminal situation at the root of 80 per cent of all the world' illnesses. Twenty-five million people die every year from waterborne diseases; 15 million of them are children.

The world population is currently 4.9×10^9 and its rate of growth over 1.6 per cent per annum. In 1985, this added 80 million people over 3 times Canada's population, to the world. Projections call for 6×10^9 in the year 2000, and a 50-60 per cent greater agricultural output to feed them.

If the major justification for the curriculum is to meet significant human needs, it is surely time that more future-oriented approaches to curriculum are urgently explored. This need not mean that subjects like mathematics lose their individual significance, especially for abler students. But it does imply that we re-design the curriculum on a different basis. Solving real problems requires input from many sources. Surely we can re-organize the overall curriculum so that the resource subjects are taught in the mornings perhaps, with interdisciplinary problems and tasks forming the application of these resources in the afternoon.

It is the author's intention to continue this process of re-design, and hopefully to develop experiences which can take advantage of the power of the microcomputer (e.g., as a spread sheet and data base) to produce innovative cooperative learning, keeping in mind the awesome dimensions of the task especially the critical need to involve representative teachers and students and demonstrate that in-service training is effective. The work of Burkhardt and Fraser in England in leading teachers into less directive roles affords a model which certainly holds promise (Burkhardt, 1986).

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PRE-UNIVERSITY EDUCATION IN CANADA

Education in Canada is a provincial responsibility. Nearly all provinces have a formal program of kindergarten followed by 12 years of schooling structured according to the following table

Stage	Grade Levels	Age Range (Nominal)
Kindergarten	K	5-6
Primary-Junior (Elementary)	1-6	6-12
Junior High	7-9	12-15
Senior High	10-12	15-18

Ontario and Quebec show variations from this pattern with Ontario students entering 4 years of High school at age 14 after Grade 8, and Quebec students going to Junior College for 2 years after Grade 11, prior to entry to University after "Grade 13".

Many of the provinces use an assessment system which is a conbination of final Grade 12 marks and teachers' assessments. Ontario, however, has no provincial-wide end-of-schooling examination, and Universities base entrance on their judgments of the marks from individual high schools.

AUTOBIOGRAPHICAL NOTE

I was educated in Scotland gaining an Honours Degree in Mathematics and Physics. After 5 years in research, I moved into secondary school teaching and did graduate study in education. I have worked in teacher education and university mathematics in Canada now for 28 years, completing a doctorate in the USA in 1964. My main work has been in curriculum development in school mathematics, with a related interest in the total school curriculum and in measurement and evaluation. I am particularly keen to see more integrated and applied work linking subjects together at the secondary level, with mathematics seen and used as a design and problem-solving tool.

TECHNOLOGICAL DEVELOPMENT AND THE RAW MATERIALS PROCUREMENT IN THE DEVELOPING COUNTRIES

Greg. O. Iwu, Professor of Industrial Chemistry (University of Benin,
Benin City, Bendel State, Nigeria)

Abstract: The application of Science and Technology education in the procurement of the local resources for the real economic development of the Developing countries has been highlighted. About 80% of Semi-manufactured and semi-processed materials required as feedstock by the industries in the developing countries is imported.

This is inspite of the fact that there are adequate potential local raw materials to sustain these industries. Wrong priority, lack of the appropriate strategy, mechanism and adequate financial investment are responsible for the failure to utilise the local raw materials for technological development of the developing countries.

Raw materials Development Centres with adequate financing are suggested to be established in the Developing Countries. Appropriate personnel in the tertiary educational institutions in the developing countries should be fully utilised in the technological development of the countries.

It has been estimated that about 80% of the industrial feedstock materials, comprising semi-manufactured and/or semi-processed materials are imported from the developed countries. This is inspite of the fact that there are adequate potential local raw materials available in these countries. On account of this unwholesome and avoidable reliance on the imported raw materials as the feed stock for the local industries, severe constraints have been imposed on the technological development of the developing countries particularly of the African continent.

A detailed analysis of the technological development vis-a-vis the industrial development pattern of the third world countries would reveal that technology acquisition involves either the transfer of the manufacturing licence to the foreign-owned subsidiaries or to the locally owned firms. Thus the locally owned or controlled industries are obliged to use multiple sources of technology, while the foreign owned industries use an integrated single source of technology. Most of these industries are secondary industries or assembly plants utilising semi-processed feed stocks imported from the developed countries. Ironically most of these semi-processed feed stocks are derived from the raw materials extracted and exported from the developing countries. If this pattern is sustained, there cannot be any genuine and realistic technological development of these countries.

In order to minimise this cycle of dependence and exploitation three major challenges have to be recognised, tackled and solved. Firstly, most of the industrial machinery and equipment were conceived and designed to handle the imported semi-processed feed-stock from the developed countries. Thus, for the machinery and the equipment to handle the local raw materials they would either be re-designed, drastically modified to cope with the parameters of the local raw materials or in the exceptional circumstances be scrapped. Alternatively additional processing facilities might be required.

Secondly in the interim, how would the developing countries maintain supply of essential goods and services from the local industries while awaiting the adjustment of their manufacturing practice and the backward integration of the industrial plants - to permit the utilization of the local raw materials.

Thirdly, having identified the appropriate local raw materials substitutes, how would the developing countries ensure that there is adequate technological capacity and financial resources to process the raw materials for the relevant industrial plants.

Incidentally nature endowed most of the developing countries with abundance of raw materials. Nevertheless, on account of the economic and political history of these countries, trans-national and multinational corporations of the developed countries are only engaged in the extraction and exportation of these essential raw materials to their home bases for processing and manufacture of finished consumable products for re-exportation to the developing countries. This is part of the reason for the stagnation of the technological developments of the third world countries. However, with the increasing economic awareness, industries are now being established in the developing countries by the Government and local indigenous and foreign enterpreneurs. Unfortunately some of the modalities used in establishing some of the core industries in these developing countries have raised some critical technical and economic questions. For example, in some instances, enough account had not been taken of the indigenous raw materials prior to the conception and design of some of the core industries in the developing countries. In some cases plants have been designed and fabricated for the utilization of imported semi-processed raw materials from the developed or vendor countries.

A typical example of this situation is the recently established Iron and Steel Complex in Nigeria. Clearly there was not enough process data on the relevant raw materials for the latter to be taken into serious account during the selection of the technology and the design of the country's Steel Plant Complexes. This is primarily the case because little or no real investment has been made on the investigation of the indigenous raw materials relevant to Iron. It is therefore understandable but unfortunate that the two Iron and Steel Plant Complexes in the country substantially rely presently on imported raw materials. This is inspite of the glaring evidence of abundance of potential local raw materials like iron ore, coal, dolomite, limestone, refractory clay, manganese ore, iron scrap and natural gas, that would more than adequately sustain the Iron and Steep Plants in the country.

Again, using Nigeria as an example, the natural gas reserves in the country are put at about 300 trillion cubic feet. About 30% of this is associated with crude petroleum oil and 70% unassociated natural gas. It is important to note that the energy status of natural gas dramatically increased from 2% in 1965 to 19% in 1980 as a primary energy source. On account of the high ratio of gas/oil during the oil extraction in Nigeria, an average of about 1000 standard cubic feet of gas is produced per barrel of oil in Nigeria. Inspite of the fact that Natural gas could be the most important raw material that could easily become a vehicle for quick and economic industrialisation of the country, nonetheless, due to lack of the technological capacity and the financial resources, over 90% of this gas is flared. The amount of gas flared daily is equivalent to 40,000 barrels of oil on energy basis.

Prior to the nationalisation of the Guyana Bauxite Complex in the Republic of Guyana in South America, the Transnational Company expanded a lot of the country's foreign exchange in the importation of wheaten flour which served as a flocculent in the Bauxite Plant operations. However, soon after the nationalisation and with adequate research and development programme and financial investment the imported wheaten flour was substituted with local cassava flour without loss of quality or impairment of plant operations. It is worthy to note that since nationalisation the technological and development capacity of this establishment has been widened and deepened and the technological spin-off has been the establishment of ancillary industries related to this strategic and core industry.

On account of historical development especially in Africa education was only aimed to create an administrative cadre to provide for clerical functions as well as to administer law and order. Thus the philosophy, attitude and approach to education curriculum have remained outside the main stream of the technological and economic development of the society. This has resulted in the economic and the productivity activities of the developing countries totally dependent on the developed countries. This largely accounts for the hunger, disease and lack of shelter apparently endemic in the developing countries.

To correct these deficiencies in the education curriculum and training concrete steps have been taken in recent times by some developing countries to good effect. The re-orientation to practical training and technological education have yielded good results in countries like Korea and Hong Kong. In the African continent, Nigeria has recently changed the philosophy and structure of its education curriculum. This is the so-called 6-3-3-4 system of education, comprising six years of primary, three years each of junior and senior secondary education respectively and finally four years of University education. This system seeks to ensure that education has concrete, practical and functional orientation and relevance to the needs of the individual and the society.

From this discussion it is clear that there are adequate potential raw materials to feed the relevant and appropriate industries for the technological development of the developing countries. What is apparently absent are the technological capacity, strategy, mechanism and the financial resources for the procurement and the processing of the raw materials as feed stock for the industries. With the appropriate education structure, in place, it is recommended that priority status be accorded to funding the development, procurement and processing of indigenous raw materials for industries in the developing countries. As a matter of fact, the production and processing of local raw materials should take precedence over the establishment of new industries in the developing countries, even if in the short-term, it implies the exportation of the semi-processed raw materials. Over and above this recommendation, both the Private and Public sectors in the developing countries should establish without delay Raw Materials Development centres.

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THE USE OF ULTRASONICS IN MEDICINE AND ITS IMPACT ON THE QUALITY OF HEALTH-CARE

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1. PRINCIPLES OF ULTRASONIC MEASUREMENT

Recently, many of the innovations in medicine have taken place because of the use of ultrasound. By definition, *ultrasound* is sonic energy at frequencies above the audible range, i.e. greater than 20 kHz.

1.1 Properties of Ultrasound

Like other forms of sonic energy, ultrasound exists as a sequence of alternate compression and rarefactions of a suitable medium (air, water, bone, tissue, etc.) and is propagated through that medium at some velocity. Its behaviour also depends on the frequency (wavelength) of the sonic energy and the density and mechanical compliance of the medium through which it travels. At the frequencies normally encountered in diagnostic applications, ultrasound can be focused into a beam which obeys the laws of reflection and refraction.

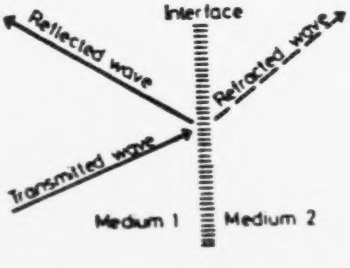

Figure 1: Reflection and refraction of ultrasound at an interface between media of different densities.

Whenever a beam of ultrasound passes from one medium to another, a portion of the sonic energy is reflected and the remainder is refracted, as shown in Figure 1. The amount of energy reflected depends on the difference in density between the two media and the angle at which the transmitted beam strikes the medium. The greater the difference in media density, the greater will be the amount reflected. Also, the nearer the angle of incidence between the beam and the interface is to 90°, the greater will be the reflected portion.

At interfaces of extreme difference in media density such as between tissue and bone or tissues and a gas, almost all the energy will be reflected and practically none will continue through the second medium. For this reason, the propagation path of ultrasound into or through the body must not include bone or any gaseous medium, such as air. In applying ultrasound to the body, an airless contact is usually produced by using an aqueous gel or a water bag between the transducer and the skin.

Table 1 lists the density and other properties of various materials, including several of biological interests. Note that the density of water and most body fluids and tissues is approximately 1.00 gm/cm^3. Benzene has a density of 0.88 gm/cm^3, wheres the density of bone is almost twice as great (1.77 gm/cm^3).

The velocity of sound propagation through a medium varies with the density of the medium and its elastic properties. It also varies with temperature. As shown in Table 1, the velocity through most body fluids and soft tissues is in a fairly narrow range around 1550 m/sec. The velocity in water is just slightly lower (1529 m/sec). Note that the velocity of sound through fat is significantly lower at 1440 m/sec, while that through bone is much higher at 3360 m/sec.

Every material has a *characteristic impedance* which is defined as the product of its density and the velocity of sound through it. Table 1 gives the characteristic impedances of several materials.

Also given in Table 1 is an *attenuation constant*, α, for each material. As ultrasound travels through the material, some of the energy is absorbed and the wave is attenuated or weakened a certain amount for each centimeter through which it travels. The amount of attenuation is a function of both the frequency of the ultrasound and the characteristics of the material. The attenuation constant, α, is defined by the equation

$$\alpha(\text{per cm}) = cf^{\beta}, \text{ where}$$

c = proportionality constant,
f = ultrasound frequency, and
β = exponential term determined by the properties of the material

This formula shows that the attenuation increases with some power of the frequency, which implies that the higher the

Table 1. Ultrasonic Characteristics of Materials*

Material	Temperature (^{o}C)	Density (gm/cm^3)	Velocity (m/sec.)	Characteristic Impedance x 10^6 ($kg/m^2/s$),β	Attenuation Constant $\alpha = cf^{\beta}$ (per cm)+
Water	40	0.992	1529	1.517	0.00025
Saline, 0.9% normal	40	0.998	1539	1.537	
Brain, average	37	1.03	1510	1.56	0.11
Muscle, skeletal	37	1.07	1570	1.68	0.13
Fat	37	0.97	1440	1.40	0.05
Bone, skull	37	1.77	3360	6.0	0.37
Liver		1.08	1510	1.63	0.19
Blood		1.01	1550	1.56	0.04
Kidney		1.04	1560	1.62	0.27
Benzene		0.88	1320	1.17	

*Modified from Welkowitz & Duestch, Biomedical Instruments: Theory & Design, Academic Press New York, 1976

+Values of attenuation constant are computed at a frequency, f, of 1MHz.

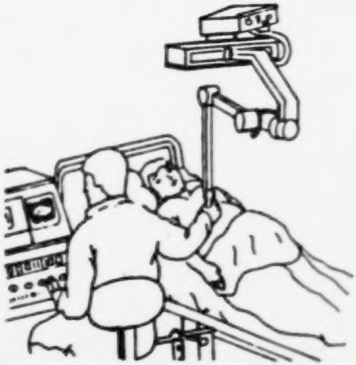

Figure 2: An ultrasound scanner in operation. The Operator moves the scanning head across the stomach, which has been lubricated with grease to aid its passage. The test is a routine check in pregnancy.

frequency, the less distance it can penetrate into the body with a given amount of ultrasonic energy. For this reason, lower ultrasound frequencies are used for deeper penetration. However, lower frequencies are incapable of reflecting small objects. Thus, for finer resolution, higher frequencies must be used. Ultrasound frequencies of 1 to 15 MHz are usually used for diagnostic purposes. At 2 MHz, distinct echoes can be recorded from interfaces 1 mm apart. Higher-frequency ultrasound is also more susceptible to scattering than ultrasound at lower frequencies. However, the high frequency ultrasound beam can be focused for greater resolution at a given depth.

1.2 Ultrasonic Generation

Sound waves suitable for diagnostic ultrasound must have frequencies in the range 1-10 MHz, and be of sufficient power so that pulse echo techniques can be used. For this frequency range and power level ultrasound is produced by the piezoelectric effect. This effect occurs in certain crystal (e.g. quartz) when they are subjected to a high electric field of several hundred volts per millimeter, which causes the crystal to distort. Crystal of quartz were used on early record players which utilised the reverse effect of mechanical distortion of the cyrstal producing an electrical signal across the crystal. Both these properties are used in diagnostic ultrasound transducers. If a high frequency electrical signal is applied to a crystal a certain amount of the energy will be converted into ultrasound; when an ultrasound beam is incident on such a crystal, the sound energy will be converted into an electrical signal. The most commonly used transducer material in ultrasonic diagnosis is the synthetic ceramic lead zirconate titanate. These piezoelectric ceramics are known as ferroelectrics; they are polarised during manufacture by applying an electric field of about 20 kV per cm across the ceramic when it has been heated to a temparature above its curie point, then slowly cooled.

When alternating voltage is applied to the surfaces of one of these transducers in the form of a disc, oscillations are set up within the disc. Some of this oscillatory energy will pass into the medium immediately in contact with the crystal, however, at the surface of the disc some energy will be reflected back. If the frequency of the applied voltage and the thickness of the disc are such that the reflected wave reinforces the next expansion of the disc the transducer is said to be operating in its resonant condition. This is the most efficient state of operation of such a transducer and is used when continuous wave operation is required. For the ferroelectric mentioned above a disc of 2 mm thickness will resonate at 1 MHz.

Ultrasonic waves penetrate the body according to the principles outlined above. The reflected waves or *echoes* are picked up by electronic circuits, amplified and chanelled to a computer for processing and analysis. The computer will produce an image of the tissue under investigation on a TV screen using an analytical technique called *Fast Fourier Transform (FFT)*. The tissues can then be examined layer by layer for details of abnormalities such as tumours, abscesses, inflammation etc., depending on the depth of penetration of the ultrasound. This provides a fast and relatively safe diagnostic tool without using Xrays or other ionizing radiation.

2. CLINICAL APPLICATIONS

Ultrasound scan serves as a method of examining the deep tissues of the body by means of high frequency sound waves. Ultrasound waves bounce off the tissues at which they are aimed at different rates according to the density of the tissues. Dense cartilage, for example, will reflect ultrasound waves at a different rate to a loosely packed fibrous tissue. This means that body tissues of different densities can be distinguished from one another.

Ultrasound scans are quick and safe, having no effect on the tissues under investigation; scans are performed in hospital out-patient clinics, or in special centres. The sound waves are generated by a hand-held piezoelectric transducer which is placed above the area to be scanned (Figure 2). The transducer records the echo of the reflected sound waves, and relays them to a computer. The computer analyses the different echoes, and displays an image of the area on a screen. Initially the use of ultrasound scans was confined to the examination of developing foetuses, but now the technique is used as an aid to the diagnosis of disorders in a number of areas.

2.1 Abdominal Ultrasound

This is the ultrasound investigation of tissues in the abdomen. The technique may be used to guide a biopsy needle to the required site, or to make a detailed examination of organs such as the liver, pancreas, kidneys and gall bladder. The gall bladder shows up particularly well, and gallstones, if present, can often be counted. An enlargement or wasting of the organs can be detected as can the presence of areas of inflammation, cysts, tumours or a blockage. For this purpose, a special ultrasound technique called *B-mode ultrasonography* is used.

2.2 Echocardiography

This is an ultrasound scan of the heart which can be used to establish the size and shape of the atria, ventricles, valves and the aorta. Recently, a modification of the technique has made it possible to observe the components of the heart during the heartbeat. This is called *real-time echocardiography*, whereby the ultrasound beam is directed at the heart in precisely timed pulses, up to 20 times a second. The result is similar to a motion picture, in which a sequence of fixed images run together to give the impression of movement.

2.3 Obstetrics & Gynaecology

The abdomen is a very convenient part of the body for ultrasound scan as there are no bony structures to interfere by absorbing the beam. In early pregnancy it is even possible to observe the amniotic sac within the uterus as early as five to seven weeks by scanning longitudinally through a full bladder which acts as a viewing chamber as it displaces the intestines. This enables foetal abnormalities, such as *placenta praevia* and breech presentation, to be detected.

A most useful measurement in obstetrics which can be performed without any harm to the foetus is the *biparietal cephalometry*. This can give an indication of the maturity of the foetus and, if made regularly during a critical period, can indicate whether growth has been retarded by placental insufficiency or is continuing at a reasonable rate. The average growth rate in the last 10 weeks of pregnancy appears to be about 0.17 cm per week.

Since obstetric ultrasound is relatively safe for both mother and baby, it is routinely given to expectant mothers attending hospital ante-natal clinics in Europe and USA. The procedure is also used to guide a needle into the womb in *amniocentesis*, or a tube into the womb in *transcervical aspiration*.

Transcervical aspiration is a recently developed method used to diagnose congenital abnormalities in the foetus while it is still in the womb. A thin tube is passed into the womb through the vagina, its precise position monitored by an ultrasound scan. When the tube is in the vicinity of the placenta, a small quantity of fluid is sucked out. This contains cells from the foetus which can be examined for signs of abnormality such as *Down's Syndrome*, *spinal bifida*, *toxoplasmosis gondii*, sequelae of maternal *Rubella* infection and other defects.

2.4 Pelvic Ultrasound

This is an ultrasound examination of the pelvic organs, most commonly used to investigate disorders affecting the womb and ovaries, such as *fibroids* or an *ovarian cyst*, or even *pelvic inflammatory disease* (PID). PID is often a sequel of untreated or undectected sexually transmitted diseases such as *gonorrhoea* or *non-gonococcal urethritis* (NGU), the latter due to infection with *Chlamydia trachomatis*.

2.5 Treatment of Meniere's Disease

Meniere's disease is a disease of the inner ear causing unpleasant attacks of dizziness and vomiting due to the imbalance of pressure within the semicircular canals. The surgical operation to cure this destroys hearing; the basis of ultrasound treatment is to irradiate the semicircular canal precisely after surgical exposure. The nerve that transmits balance information to the brain is destroyed without affecting hearing.

2.6 Parkinson's Disease

This is a disease of the central nervous system causing rigidity of limbs and unsteadiness of gait. Destruction of certain small volumes of tissue deep in the brain has been found to relieve the symptoms. The advantage of ultrasound is that it can be focused on a small volume without affecting too greatly the intervening and surrounding tissues. However, initial surgery is necessary as part of the skull must be removed to allow the passage of ultrasound into the brain without the large attenuation that bone produces.

3. ENHANCEMENT OF THE QUALITY OF HEALTH-CARE

The advent of ultrasound has rendered obsolete a number of tideous medical procedures pertaining to the detection of gall stones, kidney stones, foetal abnormalities, liver and other abscesses.

Liver abscess and gallstones can now be quickly and efficiently detected using ultrasound instead of subjecting the patient to the tideous procedure of *cholangiography*. The latter is a radiographic examination of the hepatic, cystic and bile ducts which is usually performed after an oral or intravenous administration of a radio-opaque substance.

Similarly ultrasound has enabled kidney stones to be detected without the necessity of an *intravenous pyelography* which is a radiographic visualisation of the renal pelvis, kidneys and the ureter by injection of a radio-opaque liquid.

Foetal abnormalities can now be detected and foetal growth monitored with ultrasound which are unheard of previously. In the past the detection of foetal abnormalities necessitated the use of radiographic techniques, viz. X-ray, which may prove deleterious to the foetus.

4. TRAINING OF PERSONNEL

Medical science has traditionally been the exclusive domain of doctors and those trained in the life sciences. Since the early 60's, however, the need for physicists and engineers to work alongside doctors and medical personnel has been acknowledged. In fact since the early 70's medical science has been "infiltrated" by engineers and physicists working in the peripheral but important area of Biomedical Engineering. The latter discipline has been responsible for the emergence of new technologies such as, Computerized Axial Tomography (CAT) Scan and Nuclear Magnetic Resonance (NMR), all with the sole purpose of alleviating unecessary surgery and patient discomfort leading to an enhanced quality of health-care.

Science and technology has undeniably played a very important role in all the above developments and will continue to play an active role in future endeavours in the years ahead.

At Universiti Sains Malaysia, ultrasound is taught as part of the undergraduate curriculum in the Schools of Medical Science, Pharmaceutical Science and Physical Sciences. In the Medical School it is taught at the final year undergraduate curriculum as part of the subject of Gynaecology. Students in Pharmacy have an opportunity of studying untrasound in a subject called Radiopharmacy taught at the second year level. Apart form ultrasound they are also taught some basic aspects of CAT Scan and NMR. The School of Physics has an area of specialisation called Biohhphysics where students are taught, among other aspects, ultrasound, CAT Scan, NMR as well as rudiments of nuclear medicine and health physics.

Most private (and to some extent Government-owned) hospitals have ultrasound equipment as well as CAT Scanners which are managed by radiologist specially-trained to handle such equipment. The technicians employed in these areas are also given specialised training to handle the equipment and interpret the data and images. The training is often provided overseas by the equipment manufacturers. Almost anyone with a reasonably firm technical background (not necessarily a university graduate) can be trained to handle the equipment and interpret the images.

5. CONCLUSION

At sufficiently high intensities ultrasound has a destructive effect due to its absorption by tissues. Therefore routine use of ultrasound for the frivolous aim of determining the sex of the foetus is to be discouraged. Although no harmful effects of ultrasound have been reported so far, the possibility of long term deleterious effects must not yet be dismissed.

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A. Pre-university Educational System of Malaysia

Primary education begins at age seven (Standard 1) and spans a period of six years until the child attains the age of 12 at which he will be in Standard 6 with one major examination held in Standard 5.

Secondary education begins at age 13 (Form 1) and lasts for another period of six years with three major examinations in between:

(i) The Lower Certificate of Education (LCE) at age 15 (Form 3)

(ii) The Malaysia Certificate of Education at age 17 (From 5) and

(iii) The Higher School Certificate (HSC) at age 19 (Form 6 Upper)

Students who fail to make the grade at the LCE will be retrained for another year to give them a second chance. Otherwise he may opt to go to a vocational school to acquire some trade skills. Similarly those who fail the MCE may be given a second chance, failing which they will be dismissed, or alternatively chanelled to vocational schools.

Those with good performance at the MCE Level may be chosen to enroll in Matriculation Classes overseas or locally instead of continuing with Form 6 which consists of two years of further studies.

University entrance is based on the performance at HSC or Matriculation. Those who are in Matriculation classes overseas will enroll in overseas universities while those in local Matriculation Schools (based at local universities) will enroll in the particular local university. Otherwise, for entry into local universities, all candidates will be assessed based on their performance in the HSC Examination.

For entry into science faculties candidates are expected to have principal (Advanced Level) passes in Physics, Chemistry, Biology and Mathematics with a credit in Bahasa Malaysia (i.e. the National Language) at the MCE level. A pass in the English Language at MCE level is encouraged but not mandatory.

The medium of instruction from the primary to the tertiary stage is Bahasa Malaysia (the National Language).

B. As explained previously, this paper fits into the tertiary curriculum in Mecial Science, Pharmacy and Physics at the undergraduate level in Malaysian universities. Ideally it would fit in the discipline of Biomedical Engineering/Bioengineering/Biophysics as a major area of studies. As prerequisites it would require some background in the optical properties of materials, anatomy and physiology, as well as some clinical appreication of pathology. This subject clearly demands a multi-disicipinary approach.

C. Educational Qualifications

Degrees obtained

B.Eng. (Hons) in Electrical Engineering, 1974
M.Eng. in Biomedical Engineering, 1978

Employment history

(i)	Electrical Maintenance Engineer, National Electricity Board of Malaya	1974 - 1975
(ii)	Assistant Lecturer, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Kuala Lumpur	1975 - 1978
(iii)	Lecturer, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Kuala Lumpur	1978 - 1982
(iv)	Lecturer, School of Applied Sciences, Universiti Sains Malaysia, Penang	1982 - 1984
	Lecturer, School of Engineering Sciences & Industrial Technology Universiti Sains Malaysia, Penang	1984 - 1986
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Publications

1. Measurement of Science & Technology Performance By Science & Technology Indicators. A paper presented at the ASEAN-Australian Economic Cooperation Programme in Science & Technology Policy and Project Management Symposium, Canberra, Australia. 13th April - 7th June 1985.
2. Impact of Technology Parks on Industrial Development - Australia's Experiance and REcommendations for Malaysia. A paper presented at the ASEAN-Australian Economic Cooperation Programme in Science & Technology Policy and Project Management Symposium, Canberra, Australia. 13th April - 7th June 1985.
3. Engineering Education In the Context of the Industrial Master Plan. A paper presented at the National Seminar on Engineering Education "Challenges in Engineering Education - Towards the 21st Century". Universiti Malaya, Kuala Lumpur, 29 - 30th April 1986.
4. Science Park. MIDAS Bulletin, Universiti Sains Malaysia14, no. 5/6, May/June 1986, pp. 12-17.

THE IMPACT OF INFORMATION TECHNOLOGY ON SCIENCE AND TECHNOLOGY EDUCATION

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There was once a vehicle manufacturer who set about improving the range of vehicles his company produced. After some time his R & D team came up with some very promising ideas which if implemented would give his firm the edge over all his competitors. The ideas were implemented quickly and great things were expected of the new product range. Unfortunately for this manufacturer of horse drawn carriages the introduction of the new range coincided with the development of the internal combustion engine. The rest is history.

The Information Technology typhoon - ' revolution ' is too mild a term to apply to it - which is now sweeping the globe is changing the world in which we all grew up out of all recognition. The questions this paper addresses concern the implications of this typhoon for the future of science and technology education. And in this context it is not today's pony and trap Information Technology capability that matters ; it is tomorrow's fourth and fifth generation parallel processing systems which we have to anticipate if we are to have any chance of getting that education right. As has been remarked in a somewhat different context:- "You ain't seen nothing yet".

It is not just the scale of change that poses problems for education; a quite new and un-nerving factor is the accelerating pace at which that change is taking place. When the half life of a new development may well be less than the time a student spends in secondary and / or higher education, it is not just the difficulty of trying to keep up to date that poses a problem for educators; it is also the problem of knowing whether even the concept of an up-to-date school curriculum can be sustained. In the UK, for example, some extremely exciting curriculum developments have taken place in the field of Microelectronic Technology. Educationally these may have great value; in terms of their relevance to the employment prospects of the young people experiencing them, or to the economy, they may at best be an irrelevance; at worst, an exercise in deception.

Faced with this dilemma educationalists are tending to fall into one of two camps. The first of these is what might be termed the 'eternal verities' camp. Defeated by the problem of keeping up to date, its members opt for education in 'processes' and 'skills' which are hypothesised to have some sort of timeless universal validity. The rhetoric of technology education is particularly susceptible to this approach. Yet is solving problems with micro-electronics really the same sort of activity as solving problems with string and sealing wax? The educational track record of transferable skills is, after all, nothing to write home about and there seems little reason to start believing in them now. Solving problems requires a knowledge base, not of the "We know where we can find information upon it" kind but of the "We know a subject ourselves" kind. Eric Rogers characterised this as requiring "savoir".

The other camp consists of those foolish enough to try to anticipate the future, and mould education accordingly. Since the purpose of education has always been to prepare young people for their future, this does not seem unreasonable, provided it is got right! But what does this future hold for the children entering school today? By the time many of them leave they will have crossed the threshold of the next century, assuming,that is, they survive that long!

And that of course is an assumption. It is salutary to remember that many of today's children will not be with us in 14 years time. No longer will this just be a result of inadequate diet, water supply, health care and sanitation. Unless and until some way of defeating the AIDS virus is found, it may well become endemic in communities too poor to afford condoms. Beyond this, many of the wars being fought around the world today being fought by child conscripts whose chances of survival into adulthood, either physically or psychologically whole, must be minimal. And it would only be necessary for one of these conflicts to turn nuclear for the hypothesis of a nuclear winter to be put to its ultimate test. Even those young people who survive to the year 2000 may find climactic and environmental changes associated with the depletion of the ionosphere over the polar caps, the burning of fossil fuels and the destruction of tropical rain forests causes for concern. Even if the ecosystem survives mankind's assaults, there is still the ever present possibility - probability? - that the long threatened collapse of the world economic order will occur. Should it do so it could have just as devastating an effect on humanity as any of the other potential catastrophies listed above.

The apocalyptic pessimism - realism? - of this last paragraph is, of course, incompatible with that essentially optimistic activity - education - with which this conference is concerned. Education implies hope. It implies a belief in a future. Without such a belief, why educate? How many young people have hope today? What does the future hold for them if they are anywhere other than at the top of an economic pile?

THE INFORMATION TECHNOLOGY FUTURE.

At two of the three previous IOSTE conferences I have raised the issue of the educational implications of Information Technology. It is not just an issue about harnessing the new technologies to the improvement of learning; it is also, and much more crucially, an issue about the very nature of education for the new kind of society which Information Technology is creating today. It is this latter issue with which this paper is predominantly concerned.

Information Technology is not new. With hindsight it would, perhaps, be more appropriate to refer to what we are experiencing today as "InfoTech IV". "InfoTech I" occured when the Gutenberg Bibles were printed in 1456 . "Infotech II" was heralded in by the advent of radio and telephony and "InfoTech III" by the invention of television. Each of these developments represents a quantum leap in the potential for access to information, and therefore to power. What is different about today's IT is that it encapsulates not just knowledge but also skill. This paper was prepared on a word processor. My waste paper bin is empty - which is good news for trees - and no secretary has been involved -

which may not be such good news for her/him. A skill has been eliminated and a job put at risk.

What are the implications of IT for employment? There are some, the British Prime Minister amongst them, who believe IT means more jobs, albeit not in IT. Indeed many of the jobs that are currently being created in the developed nations have three characteristics in common. They are non-tech, part-time and low-waged. The major growth area of economic activity in the UK, other than Stock Market speculation, is care of the elderly. The prospects of an InfoTech input into geriatric nursing do seem to be minimal!

In fact, the overwhelming opinion of those concerned about the impact of IT on society is that it will lead to a reduction in the demand for labour. History combines with the predictions of such diverse bodies as the Science Policy Research Unit of the University of Sussex, the Club of Rome, the US Department of Commerce and the French government's Department of Finance. All agree that the pattern of labour demands will change radically and that the net effect of all these changes will be a significant decline in demand by the beginning of the next century. One set of predictions for the UK is as follows (data in '000s):-

IT Status		1990	1995	2010	%
Med.	Agriculture,forestry,fishing (m:f 3.0)	300	290	260	-13
High	Energy and Water Supply (m:f 6.7)	600	500	400	-33
Med.	Metal industries (m:f 11.0)	240	220	200	-17
High	Chemicals (m:f 3.1)	540	550	580	+ 7
Med.	Metal goods (m:f 3.4)	310	290	270	-13
High	Mechanical Engineering (m:f 5.5)	650	550	450	-31
High	Electrical/Electronic Engineering (m:f 2.2)	750	650	500	-33
High	Motorised transport industries (m:f 8.2)	550	500	350	-36
High	Instrumentation (m:f 2.1)	100	80	60	-40
Med.	Food,drink,tobacco (m:f 1.4)	550	450	400	-27
Med.	Textiles (m:f 1.1)	200	200	160	-20
Med.	Leather,footwear and clothing (m:f 0.4)	270	250	230	-15

		1990	1995	2010	%
High	Timber, furniture (m:f 4.1)	170	140	120	-29
High	Paper, printing, publishing (m:f 2.0)	440	380	300	-32
Low	Rubber, plastics. (m:f 1.9)	220	200	200	- 9
Low	Construction (m:f 7.2)	850	1100	970	+15
High	Wholesale distribution (m:f 2.2)	800	700	500	-38
High	Retail distribution (m:f 0.6)	2000	1700	1150	-42
Low	Hotels, catering (m:f 0.5)	1050	950	900	-14
Low	Repairing goods, vehicles (m:f 3.5)	220	200	200	- 9
High	Transport and communications (m:f 4.0)	1200	1100	700	-42
High	Banking, insurance and finance (m:f 0.9)	740	600	400	-46
High	Business services (m:f 1.2)	1200	1100	700	-42
High	Public administration and defence (m:f 1.2)	1400	1200	1000	-29
Low	Sanitary services (m:f 0.6)	300	300	250	-17
Med.	Education, research and development (m:f 0.6)	1550	1550	1250	-16
Med.	Medical, health and social services (m:f 0.2)	1800	1500	1200	-33
Low	Recreational, cultural and tourist (m:f 0.9)	500	600	700	+40
Low	Personal services (m:f 0.3)	200	250	400	100

These figures derive from "Working for Leisure"; Barrie Sherman. Methuen 1986. Similar projections are being made in most other developed nations. The question of what employment impact IT may have in underdeveloped nations is returned to later in this paper.

Overall these projections are for a decrease in employment from 20.9M in 1984 to 19.7M by 1990, 18.1M by 1995 and 14.8M by 2010. Compound this with an increase of 1.4M in the number of people seeking work over this period and a very difficult social, and therefore political, scenario begins to emerge for the U.K. over the next two decades. It should also be noted that, contrary to much popular wisdom, it is employment in 'hi-tech' occupations that is most at risk. The projections for job losses in industries with a substantial 'hi-tech' component show a 35% decline in employment over this period compared with a projected 8% increase in employment in 'lo-tech' industries. It is not immediately obvious from this that education in science and technology is relevant to the vocational education of any but a tiny minority of young people being educated for life in the twenty first century. In the UK careers in accountancy, business studies, and management science are taking over from careers in science and technology as the first choice of many of our most able numerate young people. Some major industrial companies recruiting science and technology graduates are said to be selecting the best applicants for management training, the rest for research and development. It is small wonder that, despite all the rhetoric of our politicians, university engineering, science and technology departments are finding it increasingly difficult to recruit young people onto their courses. The values of a capitalist society have been well and truly learnt over the last decade.

In 1854 Herbert Spencer wrote:-

> *"For direct self-preservation, or the maintenance of life and health, the all important knowledge is - Science. For that indirect self-preservation which we call gaining a livelihood, the knowledge of greatest value is - Science. For the due discharge of parental functions, the proper guidance is to be found only in - Science. For that interpretation of national life, past and present, without which the citizen cannot rightly regulate his conduct, the indispensable key is - Science. Alive for the most perfect production and present enjoyment of art in all its forms, the needful preparation is still - Science: and for the purposes of discipline - intellectual, moral, religious - the most efficient study is, once more - Science."*

EDUCATION INTELLECTUAL MORAL AND PHYSICAL.

In the society we live in today that affirmation requires just one small change. It should now read as follows:-

> *"For direct self-preservation, or the maintenance of life and health, the all important knowledge is - Finance. For that indirect self-preservation which we call gaining a livelihood, the knowledge of greatest value is - Finance. For the due discharge of parental functions, the proper guidance is to be found only in - Finance. For that interpretation of national life, past and present, without which the citizen cannot rightly regulate his conduct, the indispensable key is - Finance. Alive for the most perfect production and present enjoyment of art in all its forms, the needful preparation is still - Finance: and for the purposes of discipline - intellectual, moral, religious - the most efficient study is, once more - Finance."*

Perhaps it was always thus!

Maynard Keynes, as long ago as the 1930's, pointed out the deskilling nature of technology. There is nothing new in this. The industrial wastelands of today have many historical precedents. Technological change has always devastated traditional industries and the communities dependant upon them. That, in the past, the developed world has been able to adapt to change is, however, no comfort to those being affected today. The pace, scale and level of sophistication associated with Information Technology change makes complacent extrapolation from past success in adaptation an exercise of very doubtful validity indeed. Are we going to be able to absorb the consequences of technological advance without rethinking the nature of society in very fundamental ways? Methods of production which reduce the demand for labour to levels unthinkable just a generation ago play havoc with so many of our long held assumptions about manufacturing. What new jobs are going to emerge? Will they be technological? How many professional occupations are already at risk from the development of 'expert systems' and will eventually be so as 'fifth generation computers come on line? Even if such systems only achieve a fraction of what is promised the future for society as we know it must be bleak indeed.

Today's young people would face a competitive situation even without the advent of Information Technology. Whether it simply exacerbates an existing situation or creates a fundamentally new scenario for employment is the real question. Does the encapsulating of human intelligence, let alone 'artificial intelligence', on a chip change the ground rules in such a way as to create a new global economic game with which neither traditional capitalism or communism can cope? In the Information Technology society in which young people are growing up today we should at least be alert to this possibility. Extrapolation has, after all, always been the least scientific of scientific processes when applied to the sciences themselves, let alone society!

Consider, for example, the multi- national company of the future, which in great measure exists today. Using its own satellite links it moves money around the world taking full advantage of fluctuating exchange rates to maximise shareholders profits. In doing this it increasingly relies on computers rather than market analysts to make decisions for it. These same satellite links are available for global managerial and executive video-conferencing and for the remote operation of Computer Aided Manufacturing systems placed strategically around the world for the benefit of the company.As the standard of automation and software engineering becomes ever more sophisticated, the need for scientific and technological competent manpower for anything other than on-site maintenance reduces still further. Making the product becomes trivial; marketing it becomes the key. We would do well to remember this and ponder on its implications for the future of science and technology education in the future. Have we, in fact, come to the end of the road?

There is, of course, another IT scenario. Individuals make use of the new technologies in a whole range of home-based 'cottage industries' provide services for the communities in which are based; jobs are created as a result of these initiatives and communities flourish as a result of the application of the new technologies. This is an appealing and romantic scenario. It is also, I have to say, a naive one. Small may be beautiful; in the real world of IT it is the big that survive. We may believe it to be desirable; it requires a fundamental change in the economic, and therefore political, order to achieve it.

INFORMATION TECHNOLOGY AND THE THIRD WORLD.

The Brandt Commission's findings laid great stress on global interdependence in removing some of the more gross inequalities between developed and underdeveloped nations. Exactly how the developments in the field of IT will assist in this is unclear. What is clear is that developments in underdeveloped countries are contingent on economic and political subservience to those who own and control IT. Thus in the past low labour costs were a considerable inducement to manufacturing industries to build plants in the less developed world. The capital intensive nature of automated industrial plant is already negating this advantage and will continue to do so. Advantageous tax arrangements are the new inducement. In contrast to this advances in the field of telecommunications are encouraging multinational companies to export routine clerical activities to low wage economies. After all why pay a clerk $200 a week in one country when another somewhere else will work for $50? Soon however why pay even that if the whole process can be automated anyhow? Clearly the economic consequences of IT are potentially catastrophic for many groups within society who only have their labour, be it physical or intellectual, to sell. That this state of affairs ought, logically, to have a destabilising effect on the existing economic order is obvious; whether it will do so seems less likely . Overall population growth - it is estimated that the Third World needs over 500M new jobs before the turn of the century - poses a far greater challenge.

Despite all this it is clear that the potential of IT to dramatically improve the quality of life of those living in the Third World is great. Global surveillance by satellite provides information about developing weather patterns, plant growth and diseases which must have potential value for any rural economy, provided it has access to that information. Satellite links and/or cheap microcomputer systems have enormous potential in fields such as education, basic health care and farming. The incorporation of skills into equipment could also be supportive of industrial development. Nevertheless all of this must be viewed against a background in which the gap between rich and poor nations is being exacerbated as a direct result of IT developments. This should surprise no one. It is the logical consequence of the competitive rather than cooperative economic system in which we operate. We have the science and technology necessary to make the world a better place. What we do not have is the politics.

SCIENCE AND TECHNOLOGY EDUCATION.

Science and Technology Educators are, by and large, great enthusiasts. All they want to do is to teach good science and technology in ways which enthuse and educate their students. Yet of their students who go on to be scientists or technologists something like 40% will be engaged in military research and development. About 400K of the world's best qualified physicists and engineers are involved in this work, most in the field of military electronics. Those who attend conferences like this need to reflect on this. The rhetoric of science and technology education very rarely reflects on the use to which it is put.

School technological projects often harness the idealism of young people to do something for such groups as the disabled and disadvantaged. Should this inspire them to go on with technology one has to say the likelihood that they will be able to develop their talents in similar humane directions is remote. The reality of the adult world is that they are far more likely to be employed in increasing the potential of mankind to create disability than to cure or alleviate it. And even in non-military activities they will be expected to engage in activities concerned more with competition and profit than with service to the community. For every technologist engaged in a genuinely socially useful activity, how many are engaged in an activity of mind boggling triviality? Of what use to anyone, except the share holders of the multinational company concerned, is striped toothpaste?

In all of this I am of course referring mainly to the way we employ our scientists and technologists in the developed world. Is the Third World any different, especially when so much of its economy is controlled by multinationals whose sole reason for existing is shareholders profit? Added to this of course must be the problem of retaining technological talent. Almost all countries in the world now experience a brain drain of their more talented young scientists and technologists. The rewards offered by the USA, Japan and by multinational companies are just as irresistible to scientists and technologists as are those offered to soccer players by Spain and Italy. Given this it should come as no surprise that the gaps between rich and poor, haves and haves not, are actually being exacerbated by the new technologies rather than reduced as they undoubtedly could be. As the Bible puts it somewhere:- "To him that hath shall be given; from him that hath not shall be taken away even that which he hath."

All of us attending this conference are products of economic, social and political systems which have been moulded by the Industrial Revolution, what Alvin Toffler conceives of as having been the "Second Wave" of change to have swept the globe, the "First Wave" having been the Agrarian revolution. It is his "Third Wave" of change - the Information Technology Revolution - with which we have to come to terms. It will not be easy. As Toffler himself puts it:-

> *"A new civilisation is emerging in our lives and blind men everywhere are trying to suppress it. This new civilisation brings with it new family styles; changed ways of working, loving and living; a new economy; new political conflicts; and beyond all this an altered consciousness as well. Pieces of this new civilisation exist today. Millions are already attuning their lives to the rhythms of tomorrow. Others, terrified of the future, are engaged in a desperate futile flight into the past and are trying to restore the dying world that gave them birth"*
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> *The Third Wave. Pan Books 1981.*

Perhaps the political move to the right which so many societies have experienced over the last decade or so is but one expression of this terror. Faced with the prospect of change it really is not surprising that we look, through rose coloured spectacles, to a past that never was to plan a future that will never be. We are all Luddites when it comes to our own particular skills. Yet the skills of the professionals - lawyers, accountants, doctors, teachers et al - are at least as much at risk as those of the lathe operators and office clerks whose displacement we have been observing with some complacency. New Technology does not just allow boring dirty jobs to be eliminated; it also has the potential to remove interesting ones. As the economist Hazel Henderson has observed:-

> *"Since the microprocessor has finally repealed the labour theory of value, there is really no possibility of maintaining the fiction that human beings can be paid in terms of their employment. The link between jobs and income has been broken."*

The implications of this truth for any society, and thus for education for life in that society are profound. In 1981 , the Department of Education and Science published a definitive pamphlet on "The School Curriculum". Its opening paragraph reads as follows:-

> *"Since school education prepares the child for adult life, the way in which the school helps her/him to develop her/his potential must also be related to her/his subsequent needs and responsibilities as an active member of our society. Parents, employers and the public rightly expect the school curriculum to pay proper regard to what the pupils will want and be called upon to do. It helps neither the children, nor the nation, if the schools do not prepare them for the realities of the adult world."*

It is impossible to quarrel with such a statement until one comes to the $64 question embedded in the last sentence:- what are these realities likely to be?

THE REALITIES OF THE ADULT WORLD.

Technological advance should be profoundly changing our view of work. We should accept this fact and act upon it. For a whole range of activities we no longer require either muscle or brain power. Yet in our schools and colleges we bemoan declining standards and do all we can to increase the scientific and technological components of our curriculum. In the UK we are so determined to go down this particular educational cul-de-sac that not only are we abandoning our traditional freedoms and forcing all pupils to spend 20% of their time studying the sciences, we are also insisting they study technology. It is really a supreme irony that just as a technology becomes available to allow us to cater for the individual interests and aspirations of young people we decide to force feed them almost identical menus. Nor is this all. It is also proposed that their ability to digest this menu be formally tested four times as they pass through the schools, at the ages of 7, 11, 14 and 16, in order to ensure they, and their teachers, conform to govermentally determined goals for the education system. This move towards centralisation, coinciding as it does with the removal of teachers democratic rights by a government whose leader appears to believe socialism to be evil has many worrying political overtones for us in the UK. Educationally with its emphasis on preparation for work, as exemplified by the well publicised but unproven Technological and Vocational Education Initiative - TVEI - it is little more than a confidence trick being played on the young people, and their parents, in the UK today.

As has been pointed out earlier, the demand for labour in the developed world is set to decline. There are ways of slowing that decline but the decline itself is inexorable. Furthermore scientific and technologically related employment will decline fastest. It is also clear that although population growth has reduced, the increased participation of women in the labour market ensures that the number of people available for work continues to rise. What consequences flow from this state of affairs?

The first and most important consequence is that political decisions have to be made about the way work is to be distributed. If the political decision is made to have a free market society then work will be distributed competitively. In such a society those lucky enough to have the right parents, to be born in the right town, to have ability or simply to have been in the right place at the right time will prosper. Others willing to work part time for subsistence wages will survive. The remainder will need to be controlled. There is nothing new in this. It is the kind of society in which almost all of us attending this conference live, even if we have had supposedly socialist governments. And why should we worry? We may not have prospered as much as we would have liked - we did after all come into education - but we are most emphatically not at the bottom of the pile. But for how long can such a society survive; for how long will the 'haves' be able to ensure that the 'have-lesses' and the 'have-nots' are happy with their lot?

In today's world nobody can be unaware of the obscene disparities in wealth which exist both between and within nations. Advances in Information Technology are, if anything, extending these disparities. And yet they are being accepted. Why? Is it because those at the bottom of the pile actually accept their lot or is it because those with power exert it effectively? They do after all control the media. At the time of Claudius the Roman calendar had 93 public holidays devoted to Games. Given that at the time there were some 400,000 unemployed and/or underemployed 'idlers' in the city the purpose of the Games was overtly political. It was to 'occupy the time of these people, provide a safety valve for their passions, distort their instincts and divert their activity. A people that yawns is ripe for revolt. The Caesars saw to it that the Roman plebs suffered from neither hunger nor ennui. The spectacles were the great anodyne for their subjects' unemployment, and the sure instrument of their own absolutism.' [Daily life in Ancient Rome. J.Carcopino.] Are Dallas and Dynasty acting as today's equivalent of those Games?

There is of course an alternative. If we accept that the need for work is diminishing there is no obvious reason why what there is should not be shared. Nor for that matter is there any reason to believe that one person's labour should be better rewarded than another's. Perhaps everyone should have the same share of a nations wealth, irrespective of their ability. After all what is ability other than a fortuitous intertwining of DNA molecules? Perhaps those whose DNA molecules intertwined less fortuitously ought in fact to have a larger share of a nation's wealth to compensate for being disadvantaged but perhaps that is taking egalitarianism too far....?

Of course in the real world neither of the extremes portrayed above could be sustained for long. Any stable system has to have within it an element of negative feedback if it is not to experience a catastrophic breakdown. The rich do have to give just enough to the poor; egalitarians do have to recognise that the able need incentives if they are to produce the goods. But once their skills have been encapsulated on a chip who needs the experts?

The fact must be faced that most young people will not need either scientific or technological knowledge and skills to operate effectively in the work place of the future. What knowledge and skills they do need are in any case far more appropriately provided by employers than by schools. Beyond this the school curriculum should reflect the declining importance of work in all our lifes. It is how we educate young people to use their time not at work that must be the key to education for the Information Technology society of the future. If work only takes up 5 hours a day, 4 days a week for eight months of the year then how do we prepare young people to use that major part of their time not constrained by work? What facilities will be available to them during that time? Instead of succumbing to the myopic vision of those who advocate a return to a past that never was to create a future that will never be we need to liberate the curriculum to take advantage of the opportunities created by the new technologies to treat young people as individuals not as employment fodder. This means, this must mean, a diverse curriculum not a common one. Young people will study not what some puritanical paternalist thinks they should study but what they actually want to study. If that is Art and Dance and Music rather than Maths and Science and Technology then so be it. And if their interests are sporting why not three days a week in the Sports Hall rather than at the desk? Surely this would offer them a much better preparation for the realities of adult life than the compulsory study of a foreign language could ever do?

It is clear from all that has gone before that I believe present trends in the curriculum to be profoundly mistaken. Information Technology actually reduces the need for education in science and technology. We are getting it wrong.

GETTING IT RIGHT.

Getting it right will undoubtedly require imagination. Others have pointed the way and this paper concludes with quotations from two of them. The first are taken from a prophetic essay written some 50 years ago; the second from a speech delivered by a reverred elder statesman some three years before he died. More than anything that is being said by today's politicians they saw the implications and opportunities created by technolical progress.

"Thus for the first time since his creation man will be faced with his real, his permanent problem - how to use his freedom from pressing economic cares, how to occupy the leisure which science and compound interest will have won for him to live wisely and agreeably and well.

The strenuous puposeful money-makers may carry all of us along with them into the lap of economic abundance. But it will be those peoples, who can keep alive, and cultivate to a fuller perfection the art of life itself and do not sell themselves for the means of life, who will be able to enjoy the abundance when it comes.

Yet there is no country and no people who can look forward to the age of leisure and of abundance without a dread. It is a fearful problem for the ordinary person, with no special talents to occupy himself.......

For many ages to come the old Adam will be so strong that everybody will need to do some work if he is to be contented. We shall do more things for ourselves than is usual with the rich today, only too glad to have small duties and tasks and routines. But beyond this, we shall spread the bread thin on the butter - to make what work there is still to be done to be as widely shared as possible. Three hour shifts or a fifteen-hour week may put off the problem for a great while......."

Maynard Keynes: Essay on the economic prospects for my grandchildren.

"The answer surely should be that the machine should work and the man should have leisure, What we want is to have four six-hour shifts and the machine to work all day long and all night long. It is that kind of thing we have to face: a completely new concept.

I foresee that in ten or fifteen years time we shall never use the word 'unemployment'. We shall refer to the proper use of leisure and how to deploy it. We shall wish to ensure that this new leisure which man at last will be able to enjoy is properly used for his mind and education, for sport and other leisure purposes. All kinds of old beliefs on all sides will have to go by the board. many old speeches will have to be torn up, and many old attitudes will have to be changed. we must approach the problem with an open mind. But if we are to achieve the intellectual revolution which is involved, we shall need also a kind of moral and spiritual revolution."

Lord Stockton (Harold MacMillan)'s Maiden Speech to the House of Lords.

Bryan R Chapman. 10: 04: 87

AN EVALUATION PARADIGM FOR SUPERVISED INDUSTRIAL-WORK EXPERIENCE IN TECHNOLOGY EDUCATION

Titus I. Eze, Ph.D ; Nigeria

Introduction

In Nigeria, technology education programs have been designed to inculcate in the youths the professional and mental acquirements required of good quality technical manpower in industries, technical colleges and research institutions. Thus, intensive practical work in industry, usually called the Supervised Industrial-work Experience Scheme (SIWES), and classroom instruction enriched with practical work have become the salient components of the programs. A major goal of this educational preparation is to produce the new generation of technical personnel whose distinctive attributes should be confidence, self-reliance, and preparedness to set-up themselves in viable small businesses. Because the SIWES is so highly regarded as a vital continuation of the students' studies, students' performance therein should be effectively evaluated.

The need for such evaluation is based on the desirability to reflect the importance of SIWES in the technology education programs, especially as it substantially contributes to the final diploma grade. Moreover, when students know that the SIWES contributes to the graduation requirement, they are more likely to show keen interest and commitment in learning the concepts and technique that determine reasonably good performance.

In technology education programs, the tasks performed by students in practical work should normally be derived from the concepts taught in the theoretical courses (see Evans & Herr, 1979; Stadt & Gooch, 1977). Nevertheless, reported researches indicate low correlations between students' performance in the theoretical work and their performance in the practical work. For example, Struit (1947) found that workshop performance grades correlated from +0.35 with written test grades. Additionally, when Abouseif and Lee (1965) correlated the results of three different practical tests on the same subject matter with those of written (theory) tests, the value of the correlations were +0.42 for the first test, -0.16 for the second test, and +0.15 for the third test.

The low correlation obtained from the foregoing studies could probably, arise from either substantial variations between the subject-matter content of the practical work and that of the theory work or from the use of poorly developed evaluation paradigm in estimating students' performance. A closer investigation of the studies reveals that the evaluation paradigms used did not capture the salient criteria for performance estimation in practical work. Although it has been noted that one of the strategies for improving the quality of the correlation between students' performance in SIWES and their performance in classroom instruction is to ensure that the contents of the work schedule used in SIWES are derived from the subject-matter of the classroom instruction (see Eze, 1985) there is the need to establish whether improved SIWES evaluation paradigm could enhance the quality of the correlation. Thus the purpose of this paper is to present an effective evaluation paradigm and hence determine the subsequent impact on the correlation between students' performances in SIWES and in classroom instruction.

THE EVALUATION PARADIGM

In SIWES, there are three major actors - the students, the academic staff and the industrial supervisor - who influence events. Because of their key roles, the contribution(s) of each in the SIWES evaluation outcome is extremely important. Specifically, the contribution of the student in the SIWES evaluation is essential from the point of view of self-evaluation (see House, 1980) which according to Stakes (1975) and Scriven (1981) is the best form of evaluation.

The academic staff and the industrial personnel who work with the students and Supervise the scheme ensure the students received valuable exposure in industry. The supervision which is an essential element of the SIWES guarantees that the students receive proper exposure to functional practical work in industry. In order to assist the students adjust easily and settle down to the work situation in industry, they are usually posted to the relevant industries in the cities where they could secure accommodation.

To evaluate the students' performance in the SIWES therefore, performance scores are measured by a combination of the scores from the following three sources;

1. The assessment by the academic staff
2. The assessment by the industry-based supervisor
3. The students' technical report.

The information banks (forms) for the first and second assessment criteria administered on a sample of students similar in academic background to the technology education students provided the test-retest reliability coefficient of +0.82 and +0.85 respectively.

Fig. 1: SIWES PERFORMANCE ASSESSMENT BY ACADEMIC STAFF

Name of Student .... Index No/Year...........
Name and Address of Industry ....

Note: Please make (x) in the space that best describes of your assessment of the student in the performance criteria listed below.

STUDENT PERFORMANCE SCORE: SIWES/001/ASAF

Performance Criteria	5 Excellent	4 Very Good	3 Good	2 Fair	1 Poor	0 Not Assessed
Ability to Learn						
Familiarity with Industrial Operations						
Creativity						
Originality						
Perserverance						
Judgement Ability						
Quality of work						
Relevance of work						
Manual Dexterity						
Discipline at work						

Total Score ....
Signature of Academic Staff ....
Name of Academic Staff (Capitals) ....
Designation .... Date ....

When the academic staff visit the students once every month at the various industrial locations for the purpose of evaluating the SIWES, they carry the Academic Staff Assessment Forms (see Fig.1) which contain selected and predetermined 10-item occupational skills which the students are expected to exhibit at the work place. The staff assess the students' performance at work, the effectiveness of the scheme and the adequacy of the training facilities. Thus the staff scruitnize the students' log books, in which the students record with diagrams the work done daily in industry, examine the work already done and the work in progress, and finally provide the assessment of each student's performance on the form. The form which is designed on a 5-point scale (Excellent, A = 5) provides that the most able student(s) could obtain a maximum of 50-points during each visit. At the end of the visits, the mean of the points earned by each student is calculated to determine the Academic Staff Assessment score for each particular student.

Fig.2: SIWES PERFORMANCE ASSESSMENT BY INDUSTRIAL SUPERVISOR

Name and Address of Industry ....
Name of Student .... Index No/Year..........

Please mark (x) in the space which best describes your assessment of the student in the performance criteria listed below.

STUDENT PERFORMANCE SCORE: SIWES/002/ISAF

Performance Criteria	5 Excellent	4 Very Good	3 Good	2 Fair	1 Poor	0 Not Assessed
Relations with others						
Application of desirable attitude to work						
Dependability						
Ability to achieve						
Industry: hard work						
Team-work						
Observance of safety						
Obedience to Instruction						
Punctuality						
Regularity of Attendance						

Total score: ....
Signature of Industrial staff ....
Name of Instrial Staff (Capitals) ....
Designation .... Date: ....

On their part, the industrial-based supervisors who usually work with the students in industry assess monthly their performance on the job using the Industry's Assessment Forms. The forms (see Fig.2) contain another set of selected 10-point occupational skills (designed on a 5-point scale) such that the most able student(s) could obtain 50-points during each assessment. The mean of all the scores for each student is computed to obtain the Industry's Assessment Score for the particular student. Additionally, each student writes and submits a concise technical report which summarises all the technical experiences (as developed from the contents of the log book) in industry. The technical report is scored on one-hundred (100) points when using the marking guide designed to assess specific occupational information required in the report.

All the assessment instruments used in this investigation have been designed by the author of this paper.

As is usual in all the subject matter courses taken in technology education programs, the performance scores for the SIWES is reported in percentages and is computed as follows;

$$100\left\{\begin{array}{l}0.25\ \text{x}\\ \text{Academic staff}\\ \text{Score}\end{array}\right\} + \left\{\begin{array}{l}0.25\ \text{x}\\ \text{Industry's}\\ \text{assessment}\\ \text{score}\end{array}\right\} + \left\{\begin{array}{l}0.5\ \text{x}\\ \text{Technical}\\ \text{Report score}\end{array}\right\} = \begin{array}{l}\text{SIWES}\\ \text{Perfor-}\\ \text{mance}\\ \text{score}\end{array}$$

In assessing the students' performance in SIWES, the research interest is to find out how much practical/technical information and occupational skill the students have been able to internalize. Naturalistic observations of their work habits during industrial visits and the consequent supervision of assigned projects may not expose as much of that as the technical report. For this reason, the technical report is weighted more than each of the other two components of the SIWES performance score. The same computational operation for obtaining the SIWES performance is repeated monthly for the duration of the SIWES, and finally the overall SIWES performance score is obtained by computing the mean of all the SIWES performance scores.

Table I: PEARSON CORRELATION COEFFICIENT OF THE SESSIONAL EXAM. SCORES WITH SIWES PERFORMANCE SCORES For 1977-1980

	SIWES 1	SIWES 2	SESS 1	SESS 2
SIWES 2	0.1802			
SESS 1	0.1458	0.1780		
SESS 2	0.2101	0.1821	0.7596*	
SESS 3	0.1582	0.0688	0.7980*	0.7737*

* $P > .01$; df = 58

Table II: PEARSON CORRELATION COEFFICIENT OF THE SESSIONAL EXAM. SCORES WITH THE SIWES PERFORMANCE SCORES FOR 1982-85

	SIWES 1	SIWES 2	SESS 1	SESS 2
SIWES 2	0.5710*			
SESS 1	0.4525*	0.5821*		
SESS 2	0.6103*	0.5741*	0.7621*	
SESS 3	0.5462*	0,3881*	0.8090*	0.7721*

* $P > .01$; df = 58

Table III: COMPARISON OF SIWES PERFORMANCE SCORES

	1977-1980 MEAN SCORE	1982-1985 MEAN SCORE	t
SIWES 1	66.65 Std.Dev.=8.39	69.98 Std.Dev.=7.89	2.29*
SIWES 2	69.89 Std.Dev.=6.36	74.32 Std.Dev.=5.86	3.97*
t	2.47*	2.63*	

* $P > 0.05$; df = 122

APPLICATION AND ANALYSIS

In a previous study (Eze, 1985), 64 students who enrolled at Kwara College of Technology, Ilorin, Nigeria between 1977-1980 in a three-year technician engineering program, in which SIWES was an intergral part of the learning experience, were exposed to SIWES and their performance was evaluated. The resulting SIWES performance scores were correlated with the performance score obtained in the corresponding sessional examinations of theory work. The Pearson Correlation Coefficients obtained were low (see Table I). Further investigations revealed that some salient performance criteria were inadvertently omitted from the performance determination instruments.

In the present study, a new evaluation paradigm in which the performance determination instruments have been improved (by including the performance criteria hitherto omitted) was used to evaluate the SIWES performance of 60 technician engineering students who satisfied the same admission requirements as the previous students. They were enrolled in the programs of the same school between 1982-1985. The SIWES performance scores thus obtained were correlated with the corresponding sessional examination scores to obtain the Pearson Correlation Coefficients shown on Table II. These were found to be higher in value, and are statistically significant at .01 alpha level. Thus students who performed well in the sessional examinations are more likely to perform well in the SIWES.

When the means of the SIWES performance for the previous and the present study were compared using a t-test at .05 alpha level, it was found that the SIWES performance scores are better when the improved evaluation paradigm is used.(See TableIII)

It should be noted that SIWES promotes the acquisition of skill, knowledge and desirable attitude to work: Skill will enhance individual job satisfaction, quality of work and overal job performance. Through knowledge individuals gain more mastery of the concepts of the workworld. Desirable attitudes ensures that the graduates will relate more appropriately to other workers and use materials and equipment more prudently. These create good mental hygiene which could optimize the good quality of life. We can therefore propose that SIWES could improve and enhance the quality of life.

CONCLUSION

The importance of SIWES in enhancing the performance of technology education students in the sessional examination and hence making them become better trained graduates should be noted and encouraged. Since better trained graduates are more likely to do good job in their work place, by being more able to practice what they have learnt, SIWES is likely to enhance the job performance and labour productivity. In other words, more goods and services are more likely to be produced by technology education graduates who have been exposed to SIWES. When more goods and services are available, the quality of life will be improved.

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AUTOBIOGRAPHY

Titus Iloduba Eze is an Assistant Professor (Lecturer) of Technology Education at the Modibbo Adama College of the University of Maiduguri, Yola, Gongola State, Nigeria; holds the B.Sc. (Hons) of the University of Nigeria, Nsukka in Industrial Technology Education (with specialisation in Electronics and Manufacturing Process) and the M.Sc. and Ph.D of the University of Illinois, Urbana-Champaign, U.S.A.

Dr. Eze has worked as the assistant Refining Engineer with the Fuel Research Group of the Biafran Research and Production (1966-1970), was a lecturer in Electronics Technology, and the Coordinator of the UNESCO sponsored supervised industrial-work experience (industrial training) program at the Kwara State College of Technology, Ilorin, Nigeria.

He now teaches Drafting and Design and Workshop practice at the Modibbo Adama College, University of Maiduguri, Yola; has published several papers in reputable journals. Dr. Eze is married to a nurse practitioner/specialist in Community health and has three children.

EDUCATIONAL SYSTEM IN NIGERIA

Majority of Nigerian children usually start the 6-year primary school at 5 and graduate about 10 or 11. Through competitive entrance examination, the most intellectually able children are admitted into the 3-year jenior secondary school, and later the 3-year senior secondary school where the children study the arts, science and technical subjects. Students who are university-bound usually continue their education at the senior secondary school while those who are not, bifurcate to the vocational technical schools where they concentrate in learning practical skills. Students are selectively channelled into courses on the basis of their aptitude and career inclinations. At the end of the senior secondary school, students sit for the West African Examination Certificate in eight subjects. Placement at the University, other tertiary institutions or jobs in Nigeria requires that students must pass (at credit level) 5 subjects relevant to the specific circumstance. University admission is through a competitive centrally organised examination of both the essay type and objective tests.

This paper is designed to assist Nigeria in re-shaping the programs in technology education so that such programs could be more useful to the society, which needs the production of goods and services. It is estimated that developing countries will find the paper useful, in developing their patterns of technology education.

POST-SECONDARY TECHNICAL SCHOOL TEACHERS' PERCEPTIONS OF THE IMPACT OF TECHNOLOGICAL CHANGE ON THEIR PROFESSIONAL ACTIVITIES

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INTRODUCTION

Technological change, which involves both products and processes and the manner in which work is performed (Stranks, 1983), has become a part of the community language creating debate at social, political and industrial levels. These changes in technology, and the subsequent new technical skills required within the economy and workforce, impinge upon the courses offered by the various educational authorities (Sungaila, 1983; Hull & Pedrotti, 1983). Changes in technology are of particular importance to the Technical and Further Education (TAFE) sphere of post-secondary technical education in Australia which is largely concerned with the preparation of technically oriented and skilled people (Caro, 1984; Tognolini, 1984; Whitehead, 1983). This is especially so in recent years when there has been an increasing awareness of the influence that new technology is having on the social and economic aspects of Australian society (Jones, 1982). As highlighted earlier by Toffler (1973), technological growth introduces new knowledge and processes to society at an unprecedented rate. However, despite considerable debate relating to the introduction of new technology into TAFE courses, the actual or perceived effects of new technology on technical teaching in Australia has received little attention. This paper describes the perceived impact of technological change on professional activities of teaching staff in one TAFE college in South Australia. Further details are reported in Tippett and Treagust (1987).

METHOD

The study was conducted among teaching staff at a large TAFE college in South Australia and data were obtained by questionnaires and interviews. A total of 180 questionnaires were distributed with a response rate of 68%, while 20 individual interviews were conducted with teaching and administrative staff. Interview transcripts were compared with questionnaire responses to improve validity and reliability of the teachers' perception on six aspects of the introduction of new technology into TAFE which were identified from a review of related literature (Tippett, 1985). These six aspects were:

1. The effect of technological change on TAFE programmes.
2. The influence of changes in technology on the curriculum and syllabus available to teachers.
3. The effect of changes in technology on teachers' level of technical expertise.
4. The influence of technological change on teacher's relationship with industry.
5. The effect of changes in technology on the adequacy of teaching facilities.
6. The effect of technological change on students' expectations of TAFE courses.

The questionnaire comprised items with both Likert and semantic differential scales and descriptive statistics were obtained for both scales. Details relating to the construction of the instrument and data analyses are reported by Tippett (1985). This paper discusses results from the Likert items and the interviews under the six aspects described above.

ANALYSIS OF RESPONSES

1. The effect of technological change on TAFE programmes.

The rate of technological change was perceived to vary across the range of TAFE programmes. In some courses, especially those related to the "hospitality" industry, several interviewees believed that there is not a perceived need for radical changes in the technology associated with the courses offered. Rather, these courses are largely concerned with developing skills and attitudes required when working within a hospitality and tourism environment, although areas such as computerised reservations are increasingly being introduced. However, in many TAFE courses, especially those courses related to mechanical and electronic engineering, there have been dramatic changes which reflect the scope and level of new technology being introduced and applied in industry on a continuing basis.

Questionnaire results indicated general agreement among the TAFE teachers that new technology is affecting their day to day teaching. While these changes were considered to be somewhat complex, 74% perceived the introduction of new technology to be a positive aspect of their professional activities with 69% considering that they had successfully introduced new technology into their courses. However, 64% of these TAFE teachers had difficulty keeping their teaching resources up to date while 19% did not.

The view that new technology has a major influence on TAFE programmes was supported by the interview results where 85% of interviewees considered that new technology has had a large effect on their area of expertise over the past 5 years. This also involved new courses that deal with the application of new technology in such areas as computing, plastics, micro-electronics and robotics. In addition, 70% of these interviewed considered that they had successfully introduced new technology into their courses over the last 5 years. This positive finding has important consequences since concerns have been expressed about the ability of TAFE teachers to adapt to change.

2. The influence of changes in technology on the curriculum and syllabus available to teachers.

The TAFE teachers appeared to be attempting to incorporate technological advances into their courses but the level and scope of syllabus documentation available to them varied from course to course. New technology has had a significant effect on the syllabus of 59% of respondents. Teachers were, however, divided in their opinions of the obsolescence of material in the syllabus, and on how well their syllabus reflected changes in technology. Responses varied for how well the syllabus reflected new technological trends: 40% considered the syllabus to be very supportive, while 26% considered that it constrained their efforts to update courses.

Interview data confirmed the questionnaire results: 50% of interviewees said that advances in technology had affected their curriculum to a large extent, while 30% considered the changes to be small in nature. Opinion was divided on the effectiveness of the curriculum in reflecting these changes: 35% indicated that their syllabus had successfully incorporated new technology, while 40% considered it had been unsuccessful. Several teachers commented on the excessive time required to initiate and adopt curriculum change. The TAFE teachers in this study share the concern on the need for an improvement in the responsiveness of the TAFE curriculum process.

3. The effect of changes in technology on teachers' level of technical expertise.

Questionnaire data indicated that 83% of the teachers considered it necessary to constantly upgrade their subject knowledge while only 7% did not. While 66% of respondents considered that new technology had effected their level of expertise (15% disagreed), 57% responded that they had been unsuccessful in maintaining their level of expertise. This study confirms the necessity for TAFE teachers to maintain their level of technical expertise, and suggests that many TAFE teachers have not maintained a sufficient level of expertise to adequately introduce new technology into their courses.

4. The influence of technological change on teachers' relationship with industry.

TAFE teachers found it difficult to maintain contact with industry and to keep in contact with technological advances. The questionnaire data indicated that 76% of teachers perceived that there have been significant changes in the processes and equipment used in industry since they had begun their teaching career in TAFE. A large percentage (58%) of respondents considered themselves to be out of touch with the latest technology in their area. In addition, almost half of the sample (48%) considered it difficult to maintain contact with industry.

The data from interviews supported these findings, although the aspect of the teacher's responsibility in maintaining liaison was an issue of some debate. Of those interviewed, 70% considered that maintaining contact with industry was important. The response related to the success of maintaining their industrial liaison varied, with 50% considering their activities in this area to have been successful, and 30% disagreeing. The lack of motivation for TAFE staff to undertake professional development programmes appeared to be a factor in the apparent low level of successful industrial liaison. In addition, part-time teachers in TAFE were seen as a valuable source of information and expertise in relation to new technology. The results of this study point to the need for an ongoing programme of industrial liaison for TAFE teachers; the current level of liaison between teachers and industry is considered inadequate.

5. The effect of changes in technology on the adequacy of teaching facilities.

TAFE teachers were concerned at the availability of adequate facilities for effective teaching of courses involving new technology. Most teachers (72%) considered that new technology has had a significant effect on the teaching facilities that they required. Opinion was divided as to the effect of these facilities on the teacher's professional activities, with 54% of the sample considering the facilities to be a constraint, while 32% saw them as assisting. Twenty nine per cent of teachers agreed that a continuous review and updating of teaching facilities was taking place while 42% disagreed.

The interview results supported the concerns expressed in the survey about the availability of adequate teaching facilities. Of those interviewed, 80% considered that the equipment required for their teaching activities had been influenced to a large degree by new technology. In addition, 50% responded that the existing facilities were inadequate for their requirements. Overall, the results of this study indicated that TAFE teachers placed central importance on the role of teaching facilities in the introduction of TAFE courses based on new technology.

6. The effect of technological change on students'expectations of TAFE courses.

A majority of teachers (69%) considered that students expect TAFE courses to be upgraded as a result of new technology while only 9% disagreed. In addition, only 13% considered that they had met the increased technological expectations of their students while 56% considered they had not. Seventy seven per cent of respondents considered that their students had more access to new technology than they did. The results of the study show that the teachers surveyed hold the view that the changing nature of technology and processes used at the workplace have increased the technological expectations of students attending TAFE courses.

RECOMMENDATIONS FOR TAFE COLLEGE ADMINISTRATORS

Recommendations derived from an analysis of the results of the questionnaire and interviews relate directly to the TAFE college which participated in the study, but the broad issues may be relevant to institutions of a similar context. The recommendations are summarised in point form:

* Areas of study within TAFE that are subject to rapid technological change should be identified and attempts made to initiate the processes required to increase the level of technology available to the teachers and students in these areas.

* Technical staff development activities and staff training and retraining need to be carried out on a regular and continuous basis.

* A criterion for the selection and promotion of new college teaching staff could be the demonstrated ability of the candidate to have responded effectively to changes in industry.

* More incentives and opportunities need to be provided for teaching staff to update their technical and technological expertise. These may take the form of regular visits or secondments to the related industry for extended periods.

* The curriculum development process needs to be streamlined to allow for the rapid introduction of changes in course content as a result of advances in technology.

- Teaching staff need to accept more individual professional responsibilities and read the appropriate journals and manufacturer's literature related to their area.

- There is an urgent need to upgrade the facilities in a number of teaching areas, especially those long established teaching areas where recent rapid changes in technology have been most evident such as mechanical engineering.

- The need for increased student access to large scale high technology equipment may be through the co-operative efforts between TAFE and industry.

CONCLUSIONS

The results of this study have highlighted the perceived effects that changes in technology are having on the professional role of TAFE teachers in one post-secondary technical college. While the findings are applicable to other TAFE colleges which offer technology based courses, a study to examine the actual effects of new technology within TAFE would need to focus on the teaching and learning processes within the classroom. A series of staff development and administrative recommendations derived from the results may assist TAFE administrators in the introduction of technological advances by focussing on the role and responsibilities of the TAFE teacher. However, it is apparent that in the final analysis the TAFE teacher plays a crucial role in the success, or otherwise, of the introduction of technological change within TAFE.

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Notes:

(a) Pre-university Educational System in Western Australia

Students enter primary school at 6 years of age for seven years (Years 1 - 7) and at the age of 13 transfer to high school for 3-5 years (Years 8 - 12). Students may leave school at the end of Year 10 but an increasing number are continuing into the last 2 years. Entrance to university is by passing a series of externally moderated examinations at the end of Year 12. The mode of assessment for university entrance has recently been reorganized to cater for the changing population of students, and to better relate the high school curricula to a changing society.

(b) Where the Paper fits into the Educational System in Australia

Colleges of Technical and Further Education (TAFE) provide post-secondary education with vocationally oriented courses. TAFE is equivalent to Vocational Education in the USA and Further Education in the U.K. The majority of TAFE courses in Australia are offered on a part-time basis and are usually taken concurrently with employment. There is provision for full time study and to a lesser extent external study.

(c) Brief Autobiographical Note

Paul Tippett (M.App.Sci., Curtin University of Technology) is a Senior Lecturer in the South Australian TAFE system. He has had extensive teaching and administration experience in TAFE in Australia and in Fiji and is on several national committees. David Treagust (Ph.D., University of Iowa, USA) is a Senior Lecturer in Science Education at Curtin University of Technology. He is interested in the introduction of technology into the science curriculum.

TECHNOLOGY EDUCATION IN THE UNITED STATES: A CASE STUDY OF A STATE IN TRANSITION

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The intent of this paper is to present an overview of the emerging national movement in technology education in the United States and more specifically to describe the early efforts in establishing a "technology program" in New York State for all students ages 12 to 15.

The recent movement to implement technology education programs was preceded by three or more decades of discussion among concerned professionals. Discussions, sometimes more appropriately called "fights", argued whether the profession should teach about industry or technology. It was not until the 1980's that the profession seriously considered technology as its content base. At the same time national attention was focused on the quality of education. Several national boards and commissions, responding to the need for such quality, considered technology, for the first time, an essential part of the curriculum. Perhaps equally important, technology was considered as more than computers and computer literacy. The reports indicated that:

> People must know about technology in order to improve the quality of many personal and professional technology- based decisions....People must understand the limitations as well as the capabilities of emerging technologies. The technologically literate person... should not believe that technology can solve all ills, nor that technology is responsible for most problems.[1]
>
> Students must be prepared to understand technological innovation, the productivity of technology, the impacts of the products of technology on the quality of life and the need for critical evaluation of societal matters involving the consequences of technology.[2]
>
> We recommend that all students study technology: the history of man's (sic) use of tools, how science and technology have been joined and the ethical and social issues technology has raised.[3]

These reports have been significant in helping those outside our field become more aware of the importance of technology and technological understanding. This growing public awareness provides a "fulcrum" for change and the revitalized profession supplies the "leverage". Only recently has the profession discovered the political leverage that resides in using "technology" and "technological literacy" as slogans.

Part of that political leverage accrued when people began to use the term "technology education" to replace "industial arts". Twenty-six state organizations now have changed their names to include technology. Twenty-one of these states use the more general term "technology" while five have taken the more restricted term "industrial technology". Name changing can be like name calling, however. A new name can become a powerful slogan (or battle cry) and can elicit emotion and support. Substantive changes in curriculum and instruction are needed before the programs reflect that new name, however.

Specific indications of such curricular change are presented graphically below. Table 1 lists forty-five courses that were offered nationally, 1985 to 1986, with the percentage of (loss) or gain shown for each course. Figure 1 indicates the ten courses with the largest increase and the ten showing the greatest decrease nationwide. A marked shift from a craft orientation to more of a technology orientaion is evident.[4]

The study suggests a growing interest in technology, and a growing implementation of technology oriented courses. Considerable inertia remains, however, because technology as a useful slogan has not been supplemented with an equally useful definition. Like other countries the U.S. is blessed, or cursed, with a surplus of definitions of technology.

COURSE	LOSS	GAIN
Graphics Arts		13.7%
Photography		31.8%
Printing		1.0%
Communications Technology		34.8%
Home Mechanics		8.1%
Fluid Power		10.7%
Industrial Materials and Processes		31.3%
Instrumentation		10.7%
Numerical Control		42.3%
Manufacturing		15.0%
Production Technology		27.8%
Robotics		63.5%
Metals (General)	(25.7%)	
Machine Shop	(22.5%)	
Sheet Metal	(24.8%)	
Welding	(13.3%)	
Foundry	(17.0%)	
Plastics		14.2%
Automotive Mechanics		14.3%
Power Mechanics		10.1%
Small Engines		8.2%
Transportation		15.0%
Construction		10.0%
Art Metal	(12.7%)	
Ceramics	(9.0%)	
Crafts	(3.3%)	
Leather	(1.0%)	
Textiles	(26.7%)	
Jewelry	(7.5%)	
Architectural Drafting		15.4%
Descriptive Geometry		3.4%
Drafting		13.7%
Engineering Drawing		15.4%
Industrial Design		10.2%
Mechanical Drawing		4.5%
Technical Illustration		14.1%
Electricity		0.0%
Electronics		23.3%
Computers		56.5%
Technology Education		13.0%
General Trade and Industry	(10.3%)	
Research and Development		37.5%
Woodworking	(2.4%)	
American Industry		33.3%
Exploring Technology		27.0%

Table 1. Courses Gaining or Declining in Interest or Enrollment

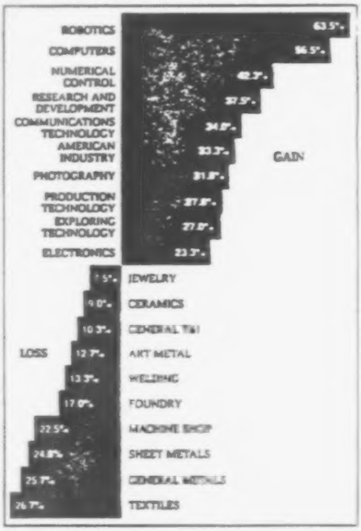

Figure 1. Courses Showing the Greatest Change

> ...the operational definitions of technology differ tremendously and range from (a) tools and hardware, (b) production of goods and services, (c) systems of construction, transportation, communication and production, (d) a body of knowledge of practical value; to (e) a philosophy of thinking and doing.[5]

No attempt will be made to defend the usefulness of several levels of definitions for technology. Instead, for the purposes of this paper one definition is stipulated for technology and another for technology education. Technology is defined here as "the use of our knowledge, tools and skills to solve practical problems to extend human capabilities."[6] Technology education is defined as "the comprehensive curriculum area which has an action based instructional program concerned with technology, its evolution, utilization, and significance;...its organization, personnel, systems, techniques, resources, and products; and their combined social and cultural impacts."[7]

Definitions alone are inadequate in that they often ignore important and significant dimensions that make technology worthy of study. Technology education must give attention to the underlying conceptual structure, function, and results of technology. Building such "conceptual models" can help a) clarify what is to be taught, b) improve how that content might be learned and organized, and c) provide these "models" as "tools" for transfering what has been learned to new and different circumstances. Such a perspective can add to the educational and political power of technology by making it important in all field as a "process" for teaching, as a "content" for study, as a "vehicle for integrated learning", as an "agent for change", and as a "commodity of value".

Within this context and milieu the New York State implementation of technology education emerged as a special case. For the first time ever in the U.S. there was a mandate that all students, in public and private schools alike, would study technology. The Regents' Mandate was actually translated into educational action through the Commissioner's Regulations. Selected key regulations are:

* One unit of technology education is required for all students completing 8th grade by June, 1988.

* Technology education means a program of instruction designed to develop an understanding of systems in fields such as production, transportation, construction, communications and agriculture by emphasizing applied activities through working with tools, machines and devices used in the home and the workplace.

* All students pursuing a Technology sequence must pass a proficiency exam before sequence credit is granted.[8]

A great deal of professional effort went into securing the Regents' Mandate. But the mandate was only the start. The development of the technology curriculum and a massive retraining program so that industrial arts teachers could become technology teachers was needed. The Technology Teacher Training (TTT) project was initiated to prepare a cadre of Technology Trainers who, working in teams of two, then set up 18 training sites across the state. During the past three years these Teams have continued their own training and have provided inservice training to approximately two thousand middle/junior high school teachers.

Currently technology programs are being planned and implemented at three different levels--elementary, junior/middle, and high school. Of the three, the junior/middle school program (7th and 8th grades--13 to 15 year olds) is furthest along in development and implementation. Next is the high school program with the elementary school program, unfortunately, a distant third. In the interest of time and space the rest of this presentation will focus on the middle/junior high school program and its implementation.

The regulations require that all girls and boys complete one unit of technology education. A unit is equivalent to a course that meets for five 42 minute periods a week for a full academic year (36 weeks). In most schools in New York State, the new curriculum is a semester of study (18 weeks) at the 7th grade and a second semester at the 8th. In a few cases there are schools that introduce technology as a subject at the 6th grade (12 year old) level. Any technology activities below the 6th grade level, although obviously important for young children, do not count toward the mandated unit of study.

The illustration below presents a general overview of the middle/junior high school technology course. During the process of feedback and curriculum modification, Module T-6 was integrated with others, resulting in a total of ten modules for the course. The first five modules introduce; 1) development, 2) resources, 3) problem solving, 4) systems, and 5) impacts of technology. The second five modules return to these key ideas with more depth particularly in the controlling of systems, problem solving, impacts and decisions.[9]

The primary delivery of the content, goals and concepts of the ten modules is through the use of Technology Learning Activities (TLAs). The TLAs were designed to take advantage of the background and skills of the teachers to be trained. Each TLA includes the essential knowledge to get the teacher started. Each TLA also includes; a) the major concepts to be addressed, b) student objectives and competencies, c) instuctional procedures, d) a set of ten "constants" to be infused into the activity (e.g. systems of technology, math, science, creative problem solving, transfer of learning.), e) references and resources, and f) evaluation examples. Example TLAs for the ten modules include the following:

Table 2. Technology Education--Seventh and Eighth Grade Modules

MODULE	*GOAL*	*FOCUS*
#T-1 Getting to Know Technology	In this module the students will explore and experience the evolution of technology for the purpose of developing an historical perspective.	■ Technology to satisfy human needs and wants ■ Physical technologies ■ Information technologies ■ Biologically-related technologies ■ Complex technologies ■ People's routines are influenced by technology
#T-2 What is Needed for Technology	In this module students will explore and experience the resources necessary for technology.	■ Resources of Technology (people, tools & machines, knowledge, capital, materials, energy) ■ Culture and technology
#T-3 How People Use Technology to Solve Problems	In this module students will explore and experience how people use technology to solve problems. They will also analyse and develop methods of using technology to benefit humankind through planning, designing, illustrating, modeling and producing.	■ Problem solving ■ Use of modeling techniques (technical drawing, sketching and illustrating, charting and graphing, computer simulations, mathematical equations, functional models, verbal descriptions.
#T-4 What Must be Known About System and Subsystems	This module is designed to provide students with a knowledge of technological systems. The student will gain an understanding of the similarities that exist among all technologies and better comprehend how technological systems are controlled.	■ Understanding simple systems model ■ Study of concepts generic to all systems ■ Construction/Operation of simple systems
#T-5 How Technology Affects People and the Environment	This module is designed to provide students with an understanding of the all-encompassing nature of technology and offer them a perception of how technology and technological change impacts directly on their lives. It should instill in students the knowledge that technology can have positive or negative impacts and that the responsibility for using technology humanistically lies with people.	■ Desirable and undesirable impacts of technology ■ Ability of people to control technology ■ Limitations of technology ■ Interaction of technological systems
#T-6 Introduction and Review	This module, will review and reinforce major concepts developed in the prerequisite technology course. [Module T1–T5]	■ People create and use technology as a means of satisfying human needs and wants ■ Three aspects of technology are biological, informational and physical ■ Technology has evolved to meet societal needs ■ All technological systems and sub-systems use resources of technology ■ Careers in technology ■ Problem solving
#T-7 Choosing Appropriate Resources for Technological Systems	This module is designed to help students choose resources from each of the resource categories based upon a set of criteria.	■ Resources of technology ■ Processes ■ Problem solving ■ Choosing appropriate resources ■ Optimizing of resources
#T-8 How Resources are Processed by Technological Systems	This module will show resources are processed by technological systems, which people use to solve their problems.	■ People solve technical problems through use of a technical process ■ Technological systems convert resources into and products ■ Conversion of resources ■ Monitoring conversion process ■ Computers for information, communicating and control.
#T-9 Controlling Technological Systems	This module is designed to provide students with an understanding of how technological systems are controlled.	■ Open loop systems and their inability to adjust to changing conditions ■ Closed loop systems use feedback ■ Control of technological systems by sensing output, comparing output, making adjustment to control ■ Computer system for controls
#T-10 Using Systems to Solve Problems	This module is to provide students with an understanding of the way in which their knowledge of systems can be used to solve problems.	■ System module to aid in problem solving ■ Solutions and their desirable and undesirable results ■ Computers as tools
#T-11 Technology and You: Impacts, Decisions and Choices	This module is designed to provide students with an understanding of the various factors involved in making decisions and choices about the selection and use of technological systems.	■ Control of technology is based upon its capabilities and limitations ■ New technologies and new careers ■ Interdependent world, resulting in: sharing resources, development of world markets ■ Impacts of technology: local, national, and global

Module	
T-6	Testing Materials Using Sensors
T-7	Food Processing Energy Processing Information Processing
T-8	Sensors and Control Controlling Technological Systems
T-9	Improving the Environment Telecommunications and Satellites
T-10	Prosthetics and Bioengineering (Ergonomics) Timeline into the Future

Module	
T-1	Early Technical Devices Time: The Fourth Dimension
T-2	Logo Design and Production Using Solar Energy to Cook Food
T-3	Energy Transfer Devices Load Bearing Structures Plants Without Parents Simulations and Modeling
T-4	Production Systems Systems and Subsystems in Model Rocketry
T-5	Hydroponic Greenhouse Habitats in an Alien Environment

The high school program will probably make less of a departure from the content and structure of the past than was made in the middle/junior high program. The experience gained through the New York State project suggests that the greater the specialization required for teaching a subject the more difficult it is to replace that subject.

Within this paper impacts has a double cannotation. The last module for both the seventh and eighth grade sylabi deals with the impact of technology. Through these modules and related activities students are helped to consider the range of consequences that technological decisions create. Consideration is given to three sets of consequences the intended and unintended, the planned and unplanned, and the desired and undesired. Special attention is turned to the unintended, unplanned and undesired as the source of surprise and trouble.

The second dimension of impact relates to the change that the New York State progam has set in motion. Following the vanguard effort in New York twenty-six other states have implemented technology education name and/or program changes. Nationally, technology education, although not quite a reality, is a growing force. More and more students now have the opportunity to become technologcally literate as the first step in coping with and hopefully learning to control technology.

And thus our profession is faced with a paradox. How can teachers make the kind of commitment needed to teach a technical subject and yet be able to move on to something new when required? Perhaps an approach to this problem for teachers is similar to the approach used in the technology program that has been designed for students. Both teachers and students need to learn specific skills within a sound conceptual framework. An important key to the problem can be found in each TLA as the tenth "constant" as the Transfer of Learning. Transferring learning, if achieved, means that students and teachers can apply their knowledge to help them understand what they currently don't know. Teaching for transfer must become a major concern for those in the profession who will train the future teachers of technology.

The New York State program and its supporting TTT project have resulted in real signs of progress. Nearly two thousand teachers have been introduced to the new 7th and 8th grade technology education program. Hundreds of teachers are now using the Technology Learning Activities. More and more teachers in the state are turning to technology as the content base. Most of this change is perceived as positive by a majority of the teachers who participated in the TTT project. In addition to all this, the vanguard endeavor in New York stimulated other states in initiating or extending their own innovations. Technology education in the United States is very young, very robust and hopefully quite ready for the hard work remaining.

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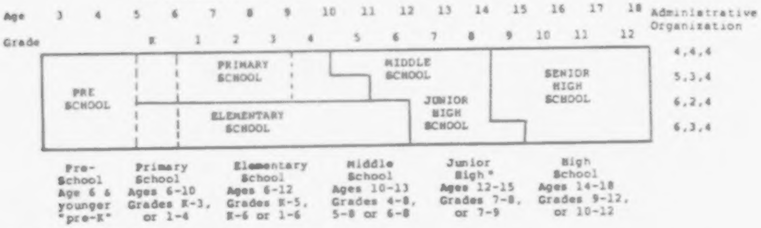
PRE-UNIVERSITY EDUCATIONAL SYSTEM OF THE UNITED STATES


Age
3
4
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6
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13
14
15
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17
18
Administrative Organization
Grade
K
1
2
3
4
5
6
7
8
9
10
11
12
PRE SCHOOL
PRIMARY SCHOOL
ELEMENTARY SCHOOL
MIDDLE SCHOOL
JUNIOR HIGH SCHOOL
SENIOR HIGH SCHOOL
4,4,4
5,3,4
6,2,4
6,3,4
Pre-School Age 6 & younger "pre-K"
Primary School Ages 6-10 Grades K-3, or 1-4
Elementary School Ages 6-12 Grades K-5, K-6 or 1-6
Middle School Ages 10-13 Grades 4-8, 5-8 or 6-8
Junior High* Ages 12-15 Grades 7-8, or 7-9
High School Ages 14-18 Grades 9-12, or 10-12

* sometimes includes 9th grade

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SYSTEM-WIDE CURRICULUM PLANNING AND EDUCATION FOR ENVIRONMENTAL RESPONSIBILITY

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(The hebrew University of Jerusalem, Rehovot, Israel)

This paper describes a way how the gap between world embracing ideas and actual involvement of pupils in the improvement of their immediate environment can be bridged by a paradigm in which central planners help school based teachers to create effective, local programs.

Some central questions.

When the Ministry of Education and Culture in Israel decided to formalize and expand Environmental Studies in upper middle schools (grades 10-12, ages 16-18), planners had to tackle, among others, some central questions, which have a bearing on the planning strategy:

- What methodological approach would be best suited?
- Which elements should be emphasized?
- How could central and local planning be integrated, in order to optimalize the advantages of both?

There was concensus that Environmental Studies should use a wide array of active learning strategies from both the natural and social sciences, e.g. case studies, outdoor and laboratory investigations, role plays and simulations. When we deal in school with local environmental issues, direct observation and experience will always play a greater part than in teaching about national or global issues. Global, environmental issues are important, but we want to treat them in the context of their world-wide implications. Therefore, the culmination in our Environmental Studies curriculum for senior high school is a project, in which students study in depth a real environmental problem in their neighbourhood and suggest how to improve the situation (Ministry of Education, 1983).

Because of its emphasis on problem solving and decision making, environmental studies demand a transdisciplinary approach (Jantsch, 1972). Teachers who were trained to handle transdisciplinary topics are rare. Most secondary school teachers do not have enough knowledge in natural and social sciences to tackle the task alone. If they dare to do it without the necessary knowledge base, their teaching becomes trivial and superficial, in the best case, and indoctrinating or misleading in the worst. To overcome these difficulties, a number of concurrent strategies are needed: e.g. team teaching and on-the-job training in project development, using suitable models.

As to the content areas and educational messages to be emphasized, it was decided to survey a representative sample of 9th grade students on their factual and conceptual knowledge, their opinions about environmental issues and the sources of their environmental knowledge. This survey (Blum, 1984) served as baseline indicator for the further development of the Environmental Studies curriculum.[1]

Among the most important insights gained from this survey were the following:

1) Students' expressed attitudes were quite positive, but not based on sound facts and concepts.
2) Students' knowledge came mainly from the mass media, and probably for this reason, their assessment of local environmental problems was considerably less accurate than that of national environmental issues. This meant, that in teaching environmental issues, the cognitive side and local aspects should be emphasized-

The identification of the needs to emphasize localized environmental issues and to help school based teams of teachers to educationally tackle these issues came about at the same time, when curriculum development in Israel and in many other countries had started to move from the highly structured curricula of the 1960s to more modular ones. This happened in Israel in Biology (Blum & Silberstein, 1979) and in other school subjects. Interesting enough, in Israel the opening up of curricula, the decentralization of curriculum development, involving local teams of teachers was more pushed from the center than from the periphery. Apparently, teachers (who often work overtime) got so much into the role of curriculum executing agents, had no training in curriculum development and did not receive incentives (time off or promotion) to devote time to curriculum development, that the push had to come from the center.

Central and decentralized curriculum planning

Although teachers had complained, in the past, about the curricula which came from "above", there were not many who jumped on the opportunity to develop their own units on local issues. This is not surprising. Many teachers do not well enough know the surroundings of their school and town. Because of the high mobility, such teachers might come from outside the school district. They might be used to teach national curricula, which can give only general advice how to organize excursions. These teachers even might have attended a curriculum implementation course at a spot familiar to the (central) course team, but without having gained the self-confidence to be able to apply the principles learned to their own environment. Locally born and bred teachers often are in no better situation.

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[1] A comparison with similar surveys conducted in the U.S., in Australia and in England is in print (Blum, 1986)

Of course, we have the "the outstanding environmental teacher" and his lucky students. In fortunate cases, this teacher is discovered by a national curriculum team and given a contract to write nationally. His or her efforts might be felt more in the capital than in the school closest to his own.

Let us not be one-sided. Central curriculum teams have certain advantages. They usually have better access to specialized sources of information and to experts. They typically have larger budgets and can collect background materials on national and international issues easier than local teachers. Central curriculum teams can also coordinate easier with national or other central examination boards.

Although local examination papers like Mode 3 in England and so-called "unique curricula" in Israel are acceptable to examination boards, they are still the exception and not always favourably looked upon by university entrance boards. Only a minority of teachers and schools are ready to invest the effort needed to create a local environmental studies curriculum or unit, and to write examination papers, although environmenmtal education is an area in which local curricula are especially warranted.

What, then, is a viable solutions? Clearly, publishing national curricula did not have the effect we hoped for. But throwing the ball to school principals and their staff, at a time of budget and manpower cuts, also did not give the wished for results, in most cases. In the following sections I shall discuss the model we used to integrate central and local curriculum development in order to optimalize the advantages of each, in the framework of the environmental studies curriculum for upper middle schools, in Israel.

The Environmental Studies curriculum model

This curriculum consists of three parts:

1) Basic concepts and a general survey of environmental issues,
2) More in-depth study of a selected environmental topic
3) A local project.

In order to enhance motivation, teachers are advised to start with identifying a local problem, usually one on which they will work later in depth (See Table 1). In the initial phase, students will quickly find out that at this stage they do not have enough "instruments" to clarify the problem and to suggest a balanced, feasible solution. Therefore, basic concepts, a systems approach and techniques of problem solving have to be studied before a real, local problem can be analyzed and tackled.

The local investigations are based on a study of a general, centrally developed introductory unit. It contains four main topics: Natural and man-made ecosystems; the development of technology (and its impact on the environment); renewable and unrenewable resources; environmenmtal planning and management.

After having received an overview on the development of environmental problems and how to approach them, students study in more depth a second unit. Teachers can choose among a series of units which were centrally developed - one which is relevant to their region. They also can develop their own, alone or with other teachers in the region, if they wish so.

Table 1
COMPLEMENTATION OF LOCALLY AND CENTRALLY DEVELOPED
CURRICULUM UNITS

Locally	Centrally
Motivation (Local Problem)	
	Unit 1 (General)
Unit 2 (Regionally Relevant)	
Project Work ("Ecotope")	
Assessment and Examination	

The peak learning experience is a project on a local or regional, environmental problem which students investigate from different angles, in order to come up with a well founded proposition, how to solve the problem. Paraphrasing the work students do on a Biotope in the framework of the Biology curriculum leading to the final examination, we refer to the environmental project as an Ecotope.

For those students who wish to include environmental studies in their matriculation ("Bagrut") examination, being questioned on their part in the Project is the major part of the examination. It can also be used to check, if students who worked on the Ecotope understood the underlying principles and knew how to apply them to the problem they investigated.

In our approach, "general" knowledge and skills are balanced with local studies. The general part, which is relevant to the country as a whole, is being prepared by a "traditional" curriculum team with ready access to sources of information which usually are not available to classroom teachers.

On the other hand, four curriculum tasks are in the hands of school based teams of teachers:

1) Identifying the local problem students will investigate,
2) Choosing the in-depth unit(s) which will serve to further prepare students for the investigation of a local issue.
3) Leading the investigation during which students should get involved in problem solving and in improving their environment.
4) Assessing the results.

In the case of Bagrut examinations, outside assessment might be added. At the moment, we deliberate the possibility to use the "follow-up examination" model which has proven itself in the practical examinations in Agriculture. According to this model, the examiner visits students while working in the field, several times during their project work. Thus the examination is not built on a one-time session with its negative psychological side-effects. Also, the examiner can act as monitor and adviser to the teacher in charge of the project.

Implementation Problems

The partly-central-partly-local curriculum development approach to environmental education (which is valid for many more topical areas in the science-technology-society syndrome) puts more responsibilities into the hands of local teachers. Four main problems have to be solved:

1) Identifying local sources of information on environmental issues which can be tapped by local teachers.
2) Training teachers in choosing modular units.
3) Training teachers in project work, including how to work with groups on different parts of a common problem.
4) Training teachers in project assessment.

Identifying local and regional sources of information who are ready to help teachers proved to be the easiest part, so far. Lately, the Society for the Protection of Nature in Israel has opened a number of field study centres in cities, some municipalities have established local services for teachers. Also Pedagogical and Science Teaching Centres have not yet been tapped to their full potential. When we organized joint meetings between volunteering subject matter specialists and teachers, the former had always the majority. Supplying the information is mainly an organisational task. The Environmental Studies curriculum development team serves as clearinghouse.

The problem how to choose among alternative curriculum units exists mainly for elementary and lower middle school teachers. For these, training materials have been developed (Silberstein, 1985). Teachers in senior middle schools should have less problems, but in any case, the issue deserves more monitoring.

The more serious problem is training for project and group work. We foresee that most teachers of Environmental Studies will come from Biology teaching. They will have had some experience in guiding students who studied a biotope. These students use to work in small groups, without necessarily having contact with other groups. This makes the teacher's task easier. In the study of an environmental topic, the questions to investigate are more complex. Various groups of students work in parallel on different aspects, sometimes geographically separated.

To train teachers in the selection of relevant topice and in group work, we started to organize groups of teachers on a regional basis. At each session, subject matter specialists from outside the school system participate.In some cases, also specialists on group work (in schools) worked with the teachers. At the same time, we further explore strategies for intensified team teaching. Centrally operating curriculum development teams have worked out suggestions how to organize teachers for team work (Barker et al, 1975; IPN, 1976; Ministry of Education, 1983), but only school-based teams can work out practical schemes, adapted to local conditions, optimalizing the inclinations, knowledge, experience and skills of the cooperating team members.

While teachers in these training groups help each other to develop the projects, they also discuss the assessment issue. Since also the examinations in Environmental Studies are new, inspectors and curriculum developers work with the teachers on assessment problems.

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The Educational System in Israel

Children attend at least for one year (aged 5) the compulsory Kindergarten. Some years ago the educational system was changed from 8 years elementary and 4 years secondary school to 6 years elementary school, 3 years lower middle school and 3 years upper middle school. About half of the country's schools underwent this change, so far. Nine school years are compulsary, but over 80% of students attend upper middle school. This can be of an academic, a vocational or an agricultural type. The majority of students learn in vocational streams. Sometimes two of these streams are combined in a comprehensive school. Able students from all types of middle schools can sit for the Bagrut Examinations which serve also for university entrance (together with a psychometric test).

This paper refers to environmental education in upper middle schools.

The author

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ATTITUDES OF POLICY MAKERS TOWARDS SCIENCE AND SOCIETY ISSUES IN A DEVELOPING COUNTRY

M.J. Kahn (University of Botswana)

1. Introduction

Science Education and the quality of life is an issue for all peoples in all cultures at all stages of development.
The issue is viewed within each local milieu, both economico-political and environmental. One cannot understand the present milieu, or plan for the future without taking the past into consideration. This paper looks at a particular local context and then considers the attitude that present policy makers have toward science and technology issues which determine the quality of life for those who make up the society. These views are contrasted with those of future science educators, namely trainee science teachers and differences in attitude are established.

2. Context

Botswana, the former Bechuanaland Protectorate, has been independent for 20 years. It is a member of the Commonwealth, and also a member of the South African Customs Union. In addition it is the host state to the Southern African Development Coordinating Committee. The nation, with its 1m people is a multi party democracy. The main human activity in this flat semi-desert of 600000km^2 is cattle rearing, and the national herd currently exceeds 3m head.
About 80% of the population lives in the rural areas and carries out subsistence agriculture. The country still possesses abundant wildlife, which in the words of the government's development plan "has yet to be fully exploited (but) meanwhile make(s) an important contribution to the subsistence economy of the country" (NDP VI,8). Repeated drought, poor soils, the system of migrant labour to the South African mines, Customs Union restrictions, as well as the drift to the towns, have led to Botswana becoming a net importer of food.
The economy is now dominated by diamond mining, and indeed, Botswana is the world's third largest producer. This wealth, which flows directly to the State, coupled with central planning in a mixed economy, has led to the establishment of a vast infrastructure embracing primary health care, education , transport and administration. Secondary industries are now emerging, towns bulge and the problems so often associated with the "third world" begin to appear.

3. National Goals

To the extent that any National Development Plan represents real intentions or realisable goals, it is worth considering the stated aims which guide government thinking.

Fundamentally, these are commitments to "rapid economic growth, social justice, economic independence, and sustained development, as well as employment creation " (NDP VI, 1986, xiii). Against this set of aims one can see the pragmatic responses of government to keep the adverse effects of development to a tolerable minimum. A National Resources Technical Committee keeps a watching brief on environmental issues such as overgrazing, soil erosion and firewood depletion. In a broader way a National Conservation Strategy has been developed to provide guidelines for sustainable development. The ways that such strategies are translated into action affecting peoples' lives are many: through legislation, the media, extension services and formal education. Indeed, all are mutually dependent on education.

4.Education

All education in Botswana is now provided free of charge, but access to education is determined by availability of school places, qualifying examinations and family commitments. About 85% of children attend primary school, but less than 10% proceed through the secondary system to completion.

Until recently, the junior secondary system was entirely geared to the needs of the minority who would advance to take "O" levels, followed by almost certain University entrance.

Unfortunately, the final component, "O" level, is an imported curriculum, externally marked and moderated. It does not fit the local context. In addition, this level of education will, in the immediate future, continue to be attained only by a minority. This is the minority which proceeds to higher level employment, probably after tertiary education.

The next level down is junior secondary education, currently available to 40% of primary entrants. Access at this level is projected to reach nearly 100% by 1991, and it is this group which is best positioned to be sensitised to environmental and social issues in science education.

5.Science Education

An aspect of the education system in Botswana which is unknown to many is the fact that, unlike many advanced Western countries, Botswana insists that all secondary pupils take a science subject. Furthermore, it is policy, if not practice, that science is taught in the last three years of primary school as well. The current move in many countries toward a "science for all" is a response to the belief that science study "contributes distinctive skills, concepts and perspectives" (ASE,1986:1) which are rightly part of every human's cultural heritage. Botswana, by contrast, has been effecting this for many years already.

As stated earlier, the Junior Secondary syllabus was tied to the needs of future "O" level pupils: "The syllabus is intended to form the basis of a course which will meet the needs of pupils proceeding to the study of Physical sciences and/or Biology for the Cambridge Overseas School Certificate (or its equivalent) as well as those who will leave school after J.C" (Ministry of

Education,1981:25):. However, the increased access to Junior Secondary education coupled with concern for relevance, has led to a major shift in thinking concerning the role of this level of education: "This new Integrated Science syllabus is written for Junior Secondary school pupils most of whom will leave formal education after Std 9/Form 2. The syllabus is therefore essentially aimed at providing pupils with knowledge, skills and attitudes needed for understanding and responsible participation in our society" (Min Ed,1985 :1).

In this radical shift in emphasis, no mention is made of the needs of the minority who proceed to "O" level, the emphasis is rather on providing a useful science having application to the real world for the majority whose formal education ends after nine years. The highly centralised Botswana education system with its centrally-authored science worksheets, allows attention to be given to social and environmental issues in conformity with another stated syllabus aim:"pupils should have knowledge of how nature can be of use to man, and at the same time be made aware of our responsibility for conserving natural resources and of guarding against pollution" (Min Ed,1985 :1).

Attention is to be given to topics such as renewable energy sources, protection of water supply, conservation, health and safety at work etc.

This sounds wonderful, presenting as it does a goal of conscientisation to such important issues, but a goal is all it is. The test is: will future generations be influenced in any way? That question is for the future to answer. We can, however, try to answer what the present attitude to these issues is.

6.Survey

In the run up to the United Nations Conference on Science and Technology for Development held in Vienna in August 1982, the Government , which required a position paper, commissioned a study on the status of Science and Technology in Botswana (Ventura,1982). The findings of this study make gloomy reading indeed. Dr.Arnoldo Ventura concluded :"Science does not appear to be a Government priority" (Ventura,1982:23). He found that: "Science in Botswana is extremely weak. There are not enough scientists even to satisfy the teaching requirements of the primary and secondary schools"(ibid:20) and complained that there was "no organised system for improving the conditions for the conduct of natural scientific research"(ibid:22).

Ventura's other main lament was that "there appears to be a very low level of scientific literacy in Botswana as a whole, stemming from the fact that this society ...is still to establish a scientific tradition" (Ventura,1982:13).To these points one can counter that there is an economic structural limitation, set by the consequences of Customs Union membership, as to what will be designated legitimate Research and Development in Botswana. Furthermore, not only scientific, literacy is still low (50%) ,and that in this situation the emergence of an independent press since 1983 provides an important information input into peoples' lives.

Nonetheless the findings are very worrying, and it was with the above in mind, as well as the need to establish some baseline evidence of how science and society issues are perceived, that a pilot survey was conducted earlier this year.
A postal questionnaire consisting of 50 items was distributed to two broad groups:
Group I: trainee diploma and degree science teachers at the University (32)
Group II: professionals (technical and managerial) and politicians (62).
The number of responses is shown in brackets.
The student group consists of third year students who had received no particular education in science and society issues. All students do, however, take such a course before completing their studies.
The professional group consists of a cross section of senior civil servants, politicians, parastatal managers, educators and private sector managers. The professional were surveyed by post, and the 50% response is gratifyingly high.
Government employs a number of expatriates in senior positions, as educators and as advisers, and these made up 20% of the professional group.
Government itself was represented by 10% of the respondees.

Questions attempted to determine some general knowledge of science; attitude to the type of science appropriate to Botswana; the role of government in science policy; environmental awareness.
The questionnaire was in two main sections - in the first respondees had to select the most appropriate of four answers to a question/statement.
In the second section, respondees were asked to rate items in importance on a 0 to 4 scale.

The main features to emerge are as follows.
i. First and foremost is the general lack of experience of all cadres: the average time in post is just 6 years, with a range of 2 to 20!

ii. One can construct a profile of the attitude toward science and technology as follows (all figures are % responses):

	I	II
-Technology leads to improvement in the quality of life	65	80
-provided it is adapted to local conditions	56	60
-and scientists exploit resources in harmony with nature.	50	65
-At school, science applications	78	45
-are more important than just the facts of science.	6	10
-For example by studying how a car engine works	59	56
-is more important than knowing how to prepare CO_2.	34	34
(Interestingly, those favouring CO_2 in II are characterised by a greater mean age than II overall.)		
-All pupils should take a science subject	69	95
-involving practical work,	87	95
-and all pupils should also take a practical subject.	97	90
-Science itself is viewed as a discipline based on		

-experiment and induction/deduction	59	43
-rather than a discipline involving testing for truth.	15	39
-Science can assist underdeveloped countries if enough		
-skilled manpower is available.	19	19
-The view that Government determines basic science needs	78	76
-is supported by a low rating of "science for its own sake	34	37
Two depressing statistics are that		
-the destructiveness of the H bomb is correctly given	69	81
-as is the global effect of a European holocaust	88	94

This set has t = 1.25 which does not constitute a significant difference below 20%.

	I	II
iii. As to quality of life and the environment, this		
is most improved by primary health care.	21	42
Science research however,is seen		
-to be a major influence on quality of life by I.	31	6
-Employment oppurtunity is also a factor in		
-determining quality of life.	21	32
-Concern about pollution was felt to be important,	69	87
-with air quality monitoring	65	87
-and acid rain assessment	47	71
a major component.		
Regarding attitudes to the environment, these were		
assessed in a number of items:		
-the worst polluter in the capital was motor exhaust	44	35
-followed by domestic wood smoke	28	32
-and litter.	22	29
-Anti-litter laws should thus be enforced	84	90
-and an alternative fuel to firewood be found.	69	84
The best-known industrial polluter is the large copper		
smelter in the north of the country.		
Both groups were in close agreement on two responses,		
-that more legislation was needed to control it	50	52
-or that the company could be relied on to take action.	34	39
(The latter view is not the general public perception!)		
Cattle have a major environmental impact on the		
fragile ecology ; cattle numbers should		
-thus be controlled to combat overgrazing.	78	89
-In addition, pesticide application should be controlled.	75	95
Exploitation of hardwood timber resources has just		
-commenced, control of timber mills is thus needed.	44	61
-Preservation of wildlife was rated as important	78	94
whereas the exploitation of the unique Okavango Delta		
-as a source of water was felt to be unimportant.	28	47

This set gives a t of 2,3 which is significant at the the 1% level.

	I	II
iv. As far as industrial health and safety is concerned,		
-the small size of industry means pollution is not		
-currently a major concern,	91	63
-which also means work hazards are not yet a problem.	72	66
There was strong support for adopting the haelth		
-and safety standards of the developed countries	78	74

-as well as drafting local standards.	75	87
That a dormant asbestos mine remain closed because of -the dust danger was supported as follows,	28	52
while control of granite quarry dust was felt to -be controllable by government laws.	91	94
The desirability of government action was identified as -appropriate to force a furniture factory to reduce dust.	16	47
(Contrast with the copper smelter above!).		
Where a factory was noisy, elimination of the hazard to -the workforce by ear defenders	69	39
-contrasts with redesign of the machinery.	9	42
The small size of industry is alternately viewed -as resulting from the small domestic market	31	58
-or with lack of scientists	38	13

The t value here is 0,45 which is also not significant.

v. All respondees seem to view the State as the dominant party in environmental issues and tend to downrate other methods of control or change.

vi. A few points are in order in comparing the differences within the professional group.
These are based on a secondary/post secondary education in science.

	sec	post sec
Correctly identify dieldrin as insecticide	40	86
Motor car engine study is useful science	48	62
Danger of asbestos	32	59
More factual science needed at school	44	16
Against use of Okavango water for irrigation	64	78

We can see some differences here but other items were not as clear-cut.

7. Conclusion

The difference in attitude toward the environment between students and professionals at the 1% level of certainty is alarming - the suggestion is that much more emphasis needs to be given to conscientisation of university students toward environmental issues. There is as yet no environmental movement as such in Botswana. Unlike the North where students have often been in the vanguard of such organisations, this awareness has yet to appear in local politics.
The message for educators is quite clear in this regard. Compared with a representative group of professionals, student teacher attitude is quite different. Students do not feel as strongly about these issues as those in the world of work.
The difference is not one arising by comparison with expatriates either; these made up barely 20% of the survey group.
The tentative suggestion to be inferred from the set of responses concerning science and technology is that Ventura's picture was overly pessimistic. The educational elite has a fairly sound

perception of science and technology, and this is shared by the next generation of science teachers. There was some indication that educational level does influence factual knowledge of general science issues, but this is to be expected.

As a follow-up, the student group will be surveyed at the end of their studies. We would hope to find some evidence of a change of attitude resulting from exposure to coursework and discussion in the area of science and society.

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9.Botswana Educational System

(Partly covered in main body of paper)

Primary = standards 1 to 7; entry at age 7. Primary School Leaving exam selects those who progress on to

Junior Secondary = forms 1 to 3; entry at age 14. Junior Certificate exam selects those who will progress on to

Senior Secondary = forms 4 & 5 . "O" level at end of form V selects those who will advance on to University study. All prospective science students take a pre-university bridging course in sciences. Access to this course is on basis of tests other than "O" levels.

This paper is concerned with aspects of University education as well as the general level of scientific literacy.

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ENVIRONMENTAL EDUCATION FROM THE PERSPECTIVE OF BROADENING THE AIMS OF SCIENCE EDUCATION

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1. INTRODUCTION

In our universe, good planets are hard to find.
Earth is such a good planet. Mankind depends on her for his very existence: food, raw materials, energy, air, soil and water, living space.
Exploitation of our environment for satisfying human needs however is causing an increasing number of environmental problems: pollution of air, water and soil, overexploitation of resources of fossil fuels and raw materials, destruction of landscapes. Problems caused by individual and collective decisions - wittingly or unwittingly - in daily life.
The need for environmental education arises: enabling students to reach (more) informed, thoughtful decisions in situations in which their behaviour or their point of view might affect the environment.
A challenge for our educational system: show our students that it's hard, but not impossible to keep our planet well.

In the Netherlands this challenge was taken up: the curriculum development project *Environmental Education in Secondary Schools* (Dutch abbr.: NME-VO) started it's work on the integration of environmental education in the science subjects and geography. In this paper we will give an outline of the project's ideas on the charactre of environmental education within the school subjects mentioned and on the consequences of the integration of environmental education in these school subjects, being a science-technology-society orientation of science education.

2. A BALANCED VIEW ON ENVIRONMENTAL EDUCATION

Curriculum development aimed at an integration of environmental education in the existing science subjects (biology, physics and chemistry) in secondary education requires an answer to (at least) the following three interconnected questions about environmental education:

- why should it be taught (a question of justification);
- what should be taught (a question of subject matter);
- what should be the effect of this teaching (a question of educational objectives)?

The answers to these three questions should provide a coherent view, on which development of a curriculum structure and teaching materials for environmental education within the science subjects can be based.

2.1 Justification

Students come across environmental issues mainly through our communication media. Sometimes the information given is one-sided. Mostly the information concentrates on topics of the day, and is (therefore) superficial and fragmentary. The relation between environmental problems and human decisions on a personal or societal level often isn't all to clearly presented. No wonder students are for example not able to identify a relation between their use of electrical energy at home and environmental problems like acid rain and the greenhouse effect. Associations of students with a 'save-energy-campaign-logan' tend to go in the direction of saving money, instead of saving our environment.

Education can broaden the students' scope of vision and can present a framework for structuring the muddle of information on environmental issues, can provide some tools to decide on a point of view or on a course of action.

These tools are *partly* to be found in the science subjects. The integration of environmental education in the science subjects is connected to one of the possible views on the aims of science education: to enable the student to cope with daily life in his/her future social role as a responsible and critical consumer and citizen in a technologically developing, democratic society. A society in which he/she permanently - wittingly or unwittingly - makes (or is asked to make) decisions on a personal or collective level, including decisions with environmental implications. Science education can contribute to a better understanding of environmental issues, a better judgment on information and a more comprehensive view on the choices to be made. (See section 4 for more detail.)

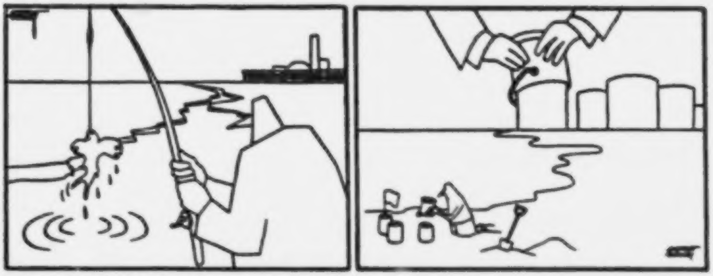
A justification like this presupposes the individual can make a contribution to tackling environmental problems by way of:

- consumer behaviour (like for example buying recycled paper (and storing used paper for recycling purposes), like traveling by bicycle or train instead of by car);
- spotting (local) environmental problems;
- putting public pressure on local, regional or (inter)national policy decisions (like for example the construction of nuclear power plants or wind turbines, setting limits to the NO_x emission of car exhausts);
- voting preference in local, regional or (inter)national elections.

This role of the individual (or a group of individuals) is recognized by society, though not always appreciated to the same extent. Motives for this recognition may be related to aspects of policy-shaping, -acceptation and -implementation (from a government point of view) or to aspects like compelling policy decisions by means of rousing public interest (from the point of view of environmental pressure groups).

2.2 subject matter

What should be taught in environmental education?
Does environmental education deal with the environment as such? Or deal with the relationship between man and the environment? Or with the actual and potential problems in this relationship? Problems like acid rain, radioactive wastes, greenhouse effect, disafforestation etc.



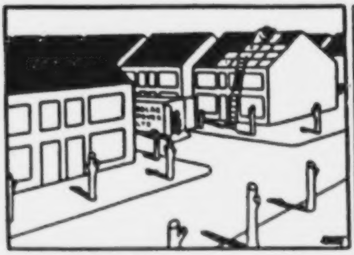
• Environmental education: improved understanding of and judgment on actual and potential problems in the relationship between man and environment?

(Cartoons by Stefan Verweij, the Netherlands)

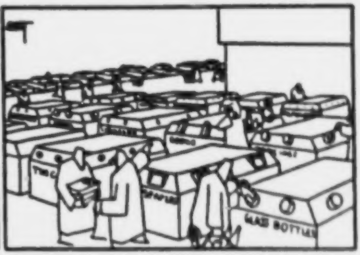
When considering the justification of environmental education given in section 2.1 it seems that knowledge about the environment as such isn't enough. The need for environmental education arises from the way in which mankind uses the environment. So environmental education has to deal with the relationship between man and the environment. But knowledge of this relationship shouldn't stand on his own: this knowledge has to bear relevance to an improved understanding of and judgment on actual and potential problems in the relationship between man and environment.

Environmental problems are rather complicated. Interpretations of the nature, causes and effects of man's intervention on the environment differ because of (scientific) uncertainties and because of differing interests. When looking at possible solutions, the following questions have to be considered:
- what are the characteristics of a lasting relationship between society and environment;
- (in which way) is this lasting relationship technically feasible;
- (in which way) is this relationship economically feasible;
- (how) is it possible to attain this relationship socially, culturally and politically?

Answering these questions means evaluating differing interests, pro's and con's: making a choice in dilemmas of a societal and personal nature. (The problem of for example household wastes can be tackled by passing laws, but also the individual can make a contribution by offering separated garbage for recycling purposes). Considering the charactre of the science subjects their contribution to environmental education is limited, because of the economical and sociopolitical aspects of environmental problems. But the science subjects certainly can contribute to clearly defining and analysing the problem and to developing blueprints for a lasting relationship, for survival.



• An environmental dilemma



• The individuals' contribution to recycling

2.3 objectives

What should be the effects of environmental education?
Does environmental education aim at developing an 'environmental awareness' and an 'ecologically sound behaviour'? Or should our educational aims be more modest?

In setting educational objectives one has to consider the limited influence education has on attitudes and behaviour of students (at least outside the schoolbuilding): school is only one of the many institutions influencing students. Besides that the question arises whether one is allowed to set specific attitudinal and behavioural objectives. As long as these objectives are rather general there is no problem (like: being able to reach more informed, thoughtful decisions on...). But as soon as these objectives become specific there is trouble (like: when confronted with a choice between public transport (bus, train) and private transport (car) the student should have a favourable attitude towards public transport). Objectives like these interfere with a highly valued freedom of individual choice. And moreover it's questionable whether attitudes can be forced on to students. It might very easily work out the other way round. One cannot force students to think that care for the environment is the most important thing on Earth. The alternative is a focus on knowledge about the environment and environmental problems and on skills (like being able to read, watch and listen critically, being able to collect and structure relevant information etc.) thus enabling students to reach a (more) informed, throughtful decision on environmental issues. Knowledge and skills as objectives for environmental education seem to be far away from the justification given in section 2.1. But what if this means extending the range of possible behavioural alternatives (things a student can do - if he/she wants to do them) and acquiring a cognitive structure on which a choice can be based?

Extending the range of possible behavioural alternatives implies that environmental education is explicit about the choices to be made on a

personal and on a societal level and is explicit about effects on the environment that accompany each choice.
But also that next to environmental concern other factors have to be taken into account when trying to reach a decision.
An approach like that, in which knowledge and skills are presented in the context of a personal or societal choice and in which the individual's influence on environmental problems is dealt, with might increase the chance of (more) informed, thoughtful decision making occuring. But: whether the student makes a choice, when he/she will do that and which way the choice turns out is his/her own responsibility.

3. CHOICES: THE CONTEXT OF SCIENCE

From what has been said in section 2 two important features of teaching materials (to be developed by the nme-vo project) can be derived:

- teaching materials are focussing on decision making situations of a personal or societal nature with environmental aspects - an *issues-based* approach;
- teaching materials are presenting science content and skills relevant for a better understanding of the choice to be made - science content and skills in (an environmental) *context*.

Decision making situations can be very close to the student, focussing on his/her social role as a consumer. Like for example the walk(wo)man as a typical battery cruncher: which type of battery is from environmental point of view the best choice, how much will that cost me, am I willing to pay that and what do I do with these batteries when they are worn out (or wouldn't it be better to buy rechargeable batteries, or maybe the thing will work on a solar cell)?
The school subjects chemistry (what kind of chemicals can be found in different types of battery - and why?), biology (what effects might dumping of worn out batteries have on the environment - like the effects of mercury on human health?) and physics (how much electrical energy is stored in different types of battery, can a solar cell give enough power?) can contribute to making a (more) informed, thoughtful choice in which not only financial motives are considered.
Another example: eating meat. Eating meat isn't questioned: it's a habit. A closer look at the production of meat (yes, it's an industry in the Netherlands: bio-industry) shows that the huge amount of manure contributes to pollution of the environment: acid rain, nitrates in ground- and surface water (and, as a result of that, in drinking water). Environmental problems not only in the Netherlands: cattle-fodder is imported from all over the (Third) world, causing (rapid) disafforestation, soil-erosion and -exhaustion. A topic for the school subjects geography (erosion), biology (why do we eat meat, is there an alternative?), physics (energy and energy-conversion) and chemistry (what's the relationship between manure and acid rain?). So there is a choice involved in eating meat. A personal choice, with implications for the environment, also on a global scale.

Decision making situations can be further away from the student, on a more societal level. Like for example the public debate on increasing the speed limit on (Dutch) motorways from 100 to 120 km/h. In the public debate the main argument against the proposed change is a decreasing traffic safety.

Environmental considerations are hardly heard. Could be a topic for physics (treatment of frictional forces (related to velocity) equalling the propelling force shows an increased energy use per km at increased velocity), chemistry (exhaust gases and acid rain) and biology (effects of acid rain on plants). This might give a broadened view on the speed limit speed issue at a societal level, but also there is a personal choice involved: you are not obliged to drive at maximum speed.

Decision making situations on a personal as well as on a societal level are numerous. They range from very narrow ones (like choosing a type of battery, the feasibility of installing a solar water heater, exchanging filament bulbs for SL-lamps etc.) to very broad ones (different scenario's for our energy-future, vanishing tropical forests, depletion of the ozone layer in the atmosphere etc.). But almost always there is a link between these two types of decision-making situation. So it is not only a question of what *one* or *they* or *we all* should do, but also a question of what *I* can do (now or later).

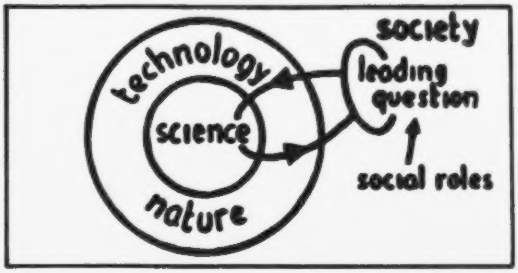
4. SCIENCE IN CONTEXT: A BROADENING OF AIMS

What are the consequences of integrating environmental education in science subjects for science teaching itself?
First of all there is a different answer to the question of 'why teach science in secondary education'.

In general science education for students aged 12-18 in the Netherlands emphasizes the development of scientific skills and an adequate mastering of scientific concepts, in order to lay down a solid foundation on which students can rely when entering those forms of tertiary education in which science knowledge is regarded essential. As a consequence science is being taught in a rather academic context, serving a minority of students who are in due time going to become a scientist themselves. For the majority of students their science knowledge and skills are of little or no practical use after leaving secondary school.
As a reaction to that there appears to be a trend towards making science teaching more meaningful, towards placing science in a personal, social and scientific context. This trend is visible in the new examination syllabi and in the teaching materials (for physics) developed by the PLON project (1, 2). Starting point for his type of science education are practical situations, derived from:

- the (future) social role of the student as a *consumer* (with the ability to cope with and make decisions about products of science and technology in daily life on aspects like quality, safety, costs, health and environmental hazards, sensible use etc.);
- the (future) social role of the student as a *citizen* (with the ability to interpret public debates and to make thoughtful judgments on controversial socio-scientific issues);
- further *studies* or (future) *employment* (of a scientific, technological etc. nature), relevant for the specific group of students (mainly in senior secondary education).

A practical situation, taken from the society students live in, gives rise to a *leading question* as an organiser for a number of science lessons (for examples of leading questions, see section 3). The leading question determines the (relevant) science content to be taught. At the end of a series of lessons the leading question turns up again: does the science content help in finding (an) answer(s) to this question, does the science content help in being able to cope with a technological device, a consumer decision, a socio-scientific issue? This turning back to the leading question (to society) is essential because it reflects the relevance of our science teaching.



• Science as one of the tools for decision making on a personal and societal level.

This type of science teaching reflects a broadening of aims: not only preparing students for further education or (future) employment (with an emphasis on an adequate mastering of scientific skills, concepts etc., and offering students an orientation on the use of science knowledge in different types of further education/employment), but also preparing students for coping with life in a technologically developing, democratic society (with an emphasis on *science as one of the tools* students can use in dealing with decision making on a personal and societal level; decisions on which buy would be best, a point of view, a course of action).

This more extended answer to the question of 'why teach science in secondary education' has some consequences for the content taught in science lessons. Teaching science in it's personal, social and scientific context doesn't change the necessity of an adequate mastering of scientific concepts; on the contrary: (more) thoughtful decision making cannot be based on badly understood scientific concepts. Wat makes the difference is that these concepts have to be looked upon (at least partly) as tools to reach other goals: (more) thoughtful decision making.
As a consequence contents and skills learned in science lessons are partly different from what is customary in a traditional approach. The leading question chosen for a teaching unit determines the (relevant) science content; in the case of speed limits for example (see section 3) this means that attention has to be paid to frictional forces, a topic that is almost completely absent in the usual approach to mechanics.
But it's not only a case of different science knowledge: we also have to include *contextual knowledge* in science lessons, like the social aspects of applications of science in society, arguments pro and con on different points of view on these applications. A very important aspect of this contextual knowledge is providing a framework for thinking about an issue. For example thinking about a sensible use of energy in the home could be guided by keeping in mind the following four aspects: task aspect (how much water

is neccesary for making tea?), efficiency aspect (SL-lamps or filament bulbs?), quality-aspect (electric, gas or solar heating?) and system aspect (combined production of heat and power, use of 'waste energy').
With regard to skills there might also be a change in emphasis. As it is not possible to cover all issues in science lessons, students have to be prepared to tackle (new) issues independently. This means they have to learn to retrieve and structure relevant information, to compare information from different sources critically etc.
So new contents and skills (besides part of the old ones), but there is one other aspect regarding content. Using science as a tool requires knowledge of the limitations of this tool. Science doesn't give all the answers (although this seems to be the case in a more traditional approach: to every question in the textbook there is one and only one correct solution). Not only because there are more factors influencing decisions (like economical, political factors), but also because of the nature of scientific knowledge. Science isn't just facts: see the controversy on the effects of low dose radiation, the uncertainties in for example the predicted rising of the sea level due to the greenhouse effect. The models describing complex systems, like the global carbon cycle, are in no way adequate (yet). Uncertainties give way to different interpretations, also by experts. Presenting an authentic image of science, science as a product of human activity in which objectivity and subjectivity are less separated domains, is a prerequisite for using science as a tool for decision making.

Teaching science in it's personal, social and scientific context as described in this section aims at an integration of science education and science-technology-society education. And environmental education fits nicely into that framework.

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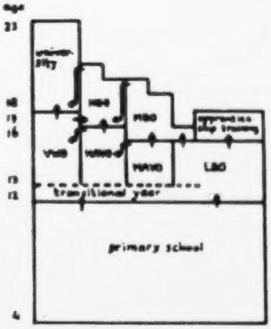
APPENDIX 1
THE EDUCATIONAL SYSTEM IN THE NETHERLANDS

The scheme represents the educational system in the Netherlands in a simplified way. After Primary School most students (70%) enter a type of general secondary education; this can be MAVO, HAVO or VWO. Some 30% of the students enter junior secondary vocational education (LBO), which consists of different types of education: commercial, home economics, agricultural, tradespeople's and technical education.

In general the science subjects physics, chemistry and biology are taught separately throughout secondary education.

The arrows indicate the possibility of continuing one's studies at an educational institution of a higher level. A certificate of a nationwide examination at the end of pre-university education (VWO) gives access to university-studies.



List of abbreviations:

VWO	pre-university education
HAVO	senior general secondary education
MAVO	junior general secondary education
LBO/MBO/HBO	junior/senior/higher vocational education

APPENDIX 2
THE PROJECT 'ENVIRONMENTAL EDUCATION IN SECONDARY SCHOOLS' (NME-VO)

The NME-VO project is a joint activity of the University of Utrecht and Groningen, the Foundation for Curriculum Development and three institutes for environmental education. The project staff is based at the Teacher Training and Educational Research Group of the Physics Department at the University of Utrecht.
The project is financed by the Ministries of Education, of Agriculture and of Housing, Physical Planning and Environment for a period of 3.5 years (January 86-August 89).
Main activities for the project staff are:

- development of examples of teaching materials for environmental education within the school subjects biology, geography, physics and chemistry for the whole range of secondary education (LBO, MAVO, HAVO and VWO; transitional year included);
- research into the effects of the teaching materials produced;
- preparation of an adequate in-service teacher training programme;
- preparation of proposals for the integration of environmental education in the examination syllabi of the school subjects at the four levels of secondary education mentioned above.

APPENDIX 3
THE AUTHOR

educational qualifications and employment history
After taking his degree in physics at the Delft University of Technology in 1973, the author worked as a physics teacher for 8 years in general secondary education (MAVO, HAVO and VWO). In 1980 he joined the Teacher Training and Educational Research Group of the Physics Department at the University of Utrecht as a curriculum developer and, after a few years, project coordinator of the Physics Curriculum Development Project (PLON). At the end of 1985, when the money for the PLON project ran out, he became coordinator of the NME-VO project.

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ENVIRONMENTAL EDUCATION: EDUCATION FOR AN ECOLOGICAL BEHAVIOUR

Elly Reinders (National Institute for Curriculum Development, Enschede, Netherlands)

"What happens to the earth
happens to the children of the earth.
If a man spits on the ground
he spits on himself.
This we know:
the earth belongs not to man.
man belongs to the earth.
This we know:
Everything is connected just as the blood
that ties a family.
All things are related

SEATTLE

Introduction

In 1986 a motorway was opened in the Netherlands. Not a spectacular event except that the motorway runs through Amelisweerd, a country estate of great natural-historical and scenic value.
An action group entered into battle with the public authorities and even now it is a classic example of running a campaign against the destruction of nature. Perhaps you have seen on television or in the newspaper the actionleaders sitting in the trees to prevent them being cut. Anyhow, the problem of sacrifying nature for motorways will be well known to most of you. The Indians of Seattles century are often cited as examples of human beings who lived in harmony with nature. The motorway through Amelisweerd is an example of manipulating nature for the sake of the economic interest of man in our western society.
Should we liken the action group to Seattle's Indians? Do they regard the earth as their mother and the air as their father? Or do they use nature in another way to realize their social and political ideals? Should environmental education guide our children to join an action group or to live as Indians? I think that we should look for solutions in accordance with our culture.
This paper gives an idea about how environmental education can contribute to that other way of appreciating nature.

Ecological thinking:

Crisis in nature is caused by the attitude of western man to nature. That attitude is a result of our way of thinking, where economic profit dominates. Nature is the raw material for the production of consumer goods and the environment is the dumpingground for the refuse of this process. To solve this crisis we need to review our way of thinking about nature and environment. A way of thinking which nature and a healthy environment are seen as essential conditions of life. A way of thinking in which man regards himself as part of a system that has links with the past, extends into the future and to places far beyond our own span of control. Human action should be defined by this notion. This way of thinking can be called **ECOLOGICAL THINKING**. Does ecological thinking fit in our culture? Or is it as alien to us as wearing feathers or smoking the peace-pipe?
Dutch farmers who have lived all their lives in close contact with nature can say things that point out that ecological thinking is not so strange in our culture. Working in their vegetable garden they told me: "I don't know why I am doing this, but I will leave this patch of ground in a better state than I found it".

And: "To me soil is the same as an animal, you must take good care of it". And with the opening of the motorway through Amelisweerd the policemen who, years before, had to keep the actiongroup away from the felling of the trees, said in an interview how emotional they felt at the sight of 600 mighty beeches falling down. But western man is so fixed upon satisfying short term needs, that any interest in 600 beeches or a clean environment for our health or the future of our children is far beyond his immediate field of vision. Environmental education should re-establish the relation between our conduct towards nature and environment on one side and our health and future on the other. You cannot fit ecological thinking into present-day education without any changes. Aimes, concepts and student-activities must be adapted to achieve another attitude to nature. There is not much optimism as to the possibility of changing attitudes within the educational system.

Changing attitudes by education:
Flemmings investigations proved that in their personal lives pupils did not use knowledge and insight gained at school. A change of attitude seems to be very hard to achieve. More-over a change of attitude does not always lead to a permanent change in behaviour. So the prospects for environmental education are not very bright. But before we loose all hope, we should take into account the following factors:

- Research into changing attitude and behaviour in education takes place, naturally, within the existing educational system, which is not open to changes. Research-projects may stimulate pupils to change attitudes during one or two lessons, but in other classes or in the period of time after the project, these stimulations are nullified.
- To change attitudes it is necessary to question the validity of norms and values. That means attention should be paid to the moral development of pupils. But in Dutch secondary education, and perhaps also in other countries, pupils are confronted with the lowest stages of moral development, that is punishment and reward. A single project or theme in which pupils are stimulated to adopt a critical attitude, a personal opinion and a sense of responsibility will be considered an isolated incident by pupils related only to a certain subject or theme.
- Another aspect is that our educational system, and that of many other countries I presume, is subject-orientated. Even in topics strongly related to social phenomena every subject deals with itself and there is no link to every day life . For pupils the usefullness of what they have learned stops when they close the schooldoor behind them. A project that brings social aspects under discussion does not alter the process at the schooldoor.
- And last but not least: the social situation does not help. An environment-friendly attitude is not the easiest road to great social and personal success in society today. In education one often thinks that when the education itself is good enough the desired change will automatically take place. But to change your behaviour demands a lot of mental energy in and out of school.

Pupils must be very motivated to be prepared to offer that energy. Must we accept that changes of attitude and behaviour are not possible? Not if we look at the success of advertising. However advertising preaches day in day out that a particular behaviour improves future-prospects, a better career, more success with partners, a better future for your children and a better old age for yourself. Environmental education should follow suit: pupils should hear daily that a healthy environment is important for their own healt, for their happiness and for their future. By means of education changed as regards content and structure.

The content of environmental-education:

It is said that environmental education can only be incorporated in the final years of secondary education due to the complex concepts and skills involved. But research (NOVAK) shows that it is possible to teach complex notions to young pupils, if you use the right didactical methods. But moreover I wonder if the complexity of a concept depends langely upon the way in which we have always approached it. Isn't the concept "ecosystem" complex just because we teach pupils from childhood to look at the part in stead of the whole, to be analytical rather than integral? In Seattle's erea Indians did not know the **WORD** ecosystem. They did not recieve environmental education. However they were familiar with the **PHENOMENON** ecosystem and dealt with it very well. The same goes for many older farmers. Likewise they did not know the word ecosystem and received no environmental education. Before the government took measures they also knew that too much dung on their fields is not good for nature.

The way they treat their vegetable garden shows a greater understanding of the ecosystem than the irresponsible manner in which they spread too much dung over their farm-land. Ecosystem may be an **ABSTRACT NOTION** in the scientific sense, but it should be possible to revert it into an **EVERYDAY PHENOMENON**. What should pupils know about everyday phenomena to handle sensible? It is not necessary to know everything about the IMF and the balance of payments to handle money sensibly. But why should pupils then describe ecosystems in terms of energy-flow, circular courses etc.? Reflection of ecosystems from system theoretical principles is only possible at the end of higher general secondary education and pre-university education, and that group is to small to solve the crisis in nature. Environmental education should give pupils form childhood the awareness that environment is important, has a value, that one has to deal with it carefully, that one can only spend it once. Environment should receive the same importance as money. In what way should the existing education change to educate pupils in that awareness? The existing science education in the Netherlands, but I pressume in other countries too, shows children the part instead of the whole. Plants are unraveled in parts that are logical in a biological sense. Root, stalk and leaf are considered in turn one after another. The plant, as a total phenomenon, in its natural environment with the organism it is related to is overlooked.

In many Dutch classrooms in secondary education pupils dissect a tulip. Why not: it is tangible, pupils are active with their hands and it has to do with every day life. Or hasn't it? For children flowers are not relevant as reproductive organs of plants. Tulips can be bought by the bunch in a flower shop, you give them to your mother on her birthday. They are one of the first signs of spring. They are a sign of happiness or sorrow. And an introduction if you visit someone. All these meanings of flowers determine the attitude of children far more than the biological meaning. So when environmental education should lead to another behaviour with nature and environment it should also incorporate these meanings. Only then can pupils make the link between what they learned and their attitude and behaviour. They should understand entities, not only all the biological or scientific roles of the object but also how that object fits into the world of a child.

Appreciation of nature:

For ecological thinking you need ecological feeling as well as ecological knowledge. Environment and the natural elements in it should have a value for the pupils. Environmental education should give the opportunity from childhood on to build up a relationship with nature. Most children start with positive feelings about nature, but education makes littles use of this fact. In the Netherlands domestic animals such as rabbits, guinea-pigs and hamsters disappeared out of the classroom, because of allergies. But the big group of "domestic animals" like snails, worms, flies and spiders could replace them very well. An aquarium is a good example of an ecosystem, and there is a lot of life in the field near the school. Children don't need rare species. Fieldwork in many forms should be part of environmental education.

A longitudinal curriculum-strategy for environmental education:

Education to ecological thinking will not succeed if it is only started in secondary education. It is a process to which should be worked at structurally.

For ecological thinking it is necessary that:

- Environment and nature get a value of their own for children
- Children learn to appreciate that environment and nature can have a different value for different people
- Children acquire an insight in the development of natural systems in time and space
- Children acquire an insight in the relations between man and environment and the different ways to approach them
- They learn to handle problems and dilemma's
- They learn to develop views of their own and to make choices

Environmental education should start early to realize these conditions for ecological thinking.

If we train our children during primary education to look at parts, then environmental education in secondary education will be very difficult.

Primary education:

Primary education can work at development of values i.e., allowing children to experience their environment and the natural elements in it. By making them aware of what they do and what they think is nice and important to live in that environment. They become acquinted with other values that people can have for nature and its value for plants and animals.

Primary education can pupils introduce to and become familiar with relations and developments in nature as phenomena. And with the part man played in creation of their environment.

In short: environmental education in primary education should focus on vaulue-development, introduction and the pupils familiarity with the environment.

Secondary education:

Secondary education should continue value-development by working and learning in the environment and awakening feelings and interests in the pupils themselves. Secondary education should systematically work on knowledge and understanding of relations and development. In the lower classes problems and dilemma's can be presented as phenomena.

In the higher classes a confrontation with problems and dilemma's

should lead to solutions, to choices, and points of view.
A more scientific approach of man - environment relationships is more appropriate.
In short: environmental education in secondary education should focus on value-development, development of knowledge and understanding, handling problems, dilemma's and making choices.
The above described structure can lead to an integral environmental-education, in which the conditions for ecological thinking are structurally achieved. It seems worth while to realize such an integration of environmental education in the existing school-system, thus within the existing subjects.
One can call this a **LONDITUDINAL CURRICULUM** strategy for environmental education.

Is such a longitudinal strategy possible and necessary in the existing educational system?

A few decades ago one Sputnik considerably strengthened the position of science education in the western world.
Why shouldn't a global crisis in nature do the same? Besides a crisis there should also be a social movement.
I think this movement exists. Education should take its turn in making social phenomena and developments with regard to environment, understandable and manageable. That is possible within the existing subjects, if the contents are chosen because of their importance in personal and social life. The desired attitude should determine the choice of knowledge and skills. But why is it not sufficient to incorporate from time to time a theme such as acid rain or air-pollution in the existing program?
Then the analysing and manipulative way of treating nature keeps the upperhand. That does not alter attitudes.
Environmental education as an ever present theme in different subjects gives pupils a more real and differentiated idea of life. It teaches pupils to cope with various views and equips better for life. Environmental education as an ever present them should make a motorway through a nature reserve as strange as a motorway through Rembrandt's Nightwatch. Then we can speak of ecological thinking.

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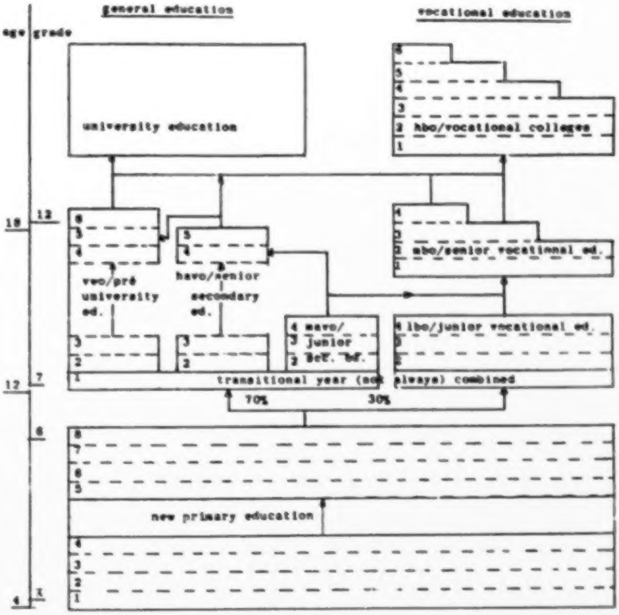
SCHEME OF FULL TIME EDUCATION IN THE NETHERLANDS


general education
vocational education
age
grade
university education
hbo/vocational colleges
vwo/pré university ed.
havo/senior secondary ed.
mbo/senior vocational ed.
mavo/ junior sec. ed.
lbo/junior vocational ed.
transitional year (not always) combined
70%
30%
new primary education
18
12
12
7
6
4
1

The discussion about environmental education is on foot in the Netherlands in primary as well as in secondary education. But primary and secondary education are strictly separated, even in curriculum development. The educational subjects are also strictly separated in the Dutch educational system.
This paper gives suggestions how environmental education should be implemented within that system.

Elly Reinders (1950) did her Masters Degree in biology at the Free University in Amsterdam. She is working as a biology teacher at a Highschool and at the National Institute for Curriculum Development (SLO) at Enschede. She is also one of the authors of the schoolbook Exact-biology.
This paper was presented at the first National Congress, on Environmental Education and published in the Dutch journal "Milieu Educatie" (Environmental Education).

PROBLEM-SOLVING AND DECISION-MAKING IN SCIENCE-TECHNOLOGY-ENVIRONMENTAL-SOCIETY (STES) EDUCATION

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Introduction

Although science, and particularly technology affect and disturb the economic, social, environmental, cultural, and political aspects of human existence, and are useful in establishing what we can do, neither of them can tell us what we should do. "What should be done" - is a matter of value judgement to be applied within the context of our society and life. It is in essence a continuous process of decision making (Zoller, 1982).

For more than a decade various modes of Science-Technology-Society (STS) programmes have been proposed to offer a new educational orientation which would compensate and complement the formal traditional science education in response to the current and future pressing needs of modern societies and all people (Zoller & Watson, 1974; Aikenhead, 1980; Association for Science Education, 1981; Harms & Yager, 1981; McConnel, 1982; Layton et al., 1986). Recently several perspectives for a conceptual framework to guide the development and implementation of STS curricula and teaching methods/strategies - have been advanced (Zoller, 1978, 1983; Yager, 1984; Bybee, 1985; Waks & Prakash, 1985; Aikenhead, 1986). These perspectives, in fact, mutually complement each other.

Science, Technology, Environment, and Society (STES) can be envisioned as the major components of the general framework of a science education programme which simultaneously deals with the context in which we live and the frame of reference of the reality we experience. In considering the importance of the environment and environmental education (EE) and their contribution to the quality of our life (Zoller, 1984), the relevant paradigms of EE have been integrated with those of STS to introduce a focus on the interaction of Science, Technology, Environment, Society (STES) into school science curricula. STES education is thus the extension of the scope of both EE and STS education by means of one synergistic comprehensive model, under the umbrella of a unified conceptual framework.

The aim of this paper is not only to advocate STES education as a vital-essential component of contemporary and future science education for all (primary, secondary, tertiary, and informal adult education), but also to deal critically with some selected theoretical and practical issues of such an education. These issues will be examined from the pragmatic point of view of the practitioner; that is, science curriculum developers, science educators and science teachers.

The Problem-Solving-Decision-Making Act in STES Education

Students (and apparently teachers) are lacking in problem-solving (PS) and decision-making (DM) proficiencies in the context of the "real world". Although the development and improvement of PS and DM capabilities in students do not constitute an integral part of traditional science teaching, students as well as adults are expected to become actively involved in social, scientific-technological, environmental and political issues and problems and their possible resolutions as competent problem solvers and decision makers regardless of their future role in society. The need of STES education to be responsive to the above challenge is clear.

A major issue of concern is that each of the four components of STES - and, all of them together as a frame of reference, - are conceptualized differently by, different people, groups, and societies. Consequently, STES education and its objectives may mean different things to different people and groups contingent on their particular contextual framework and set of local constraints.

It is useful, therefore, to define science, technology, and the environment as well as their major features in the context of STES education. Working definitions - to be considered as possible first approximations are as follows:

Science: A conceptual framework of interpreting the physical world and its manifestations in terms of testable, falsifiable statements and theories supported by evidence and data.

Technology: The macro system of technical, organizational, and institutional interrelationships between man (and man-made objects, tools, and subsystems) and his environment (which constitutes a major factor in determining the materialistic standard of living and aspirations of individuals, nations, and societies in the modern world).

Environment: The collection of immediate and remote natural, human, and man-made systems within which we live - the impact of applied technologies on which determines its quality and, consequently, the quality of our life.

The way(s) in which one conceptualizes the above features of STES in a given context is crucial, because the "bottom line" of the major concerns of all those who advocate STS and/or EE education is the 'problem-solving (PS),decision-making (DM) act' (Zoller, 1986) particularly with respect to pressing controversial issues related to the interactions of science-technology-environment-society.

Any course of action expected to be taken by the students (the future citizens) who have been exposed to SE, EE, STS or STES education is believed to be dependent on their corresponding functional literacy (Layton et al., 1986). Thus, the 'STES-PS-DM act' (i.e. the overall expected outcome of STES literate students can be summarized in terms of the following steps:

1. Ability to look at a problem (a societal issue in the STES context) and its implications, and recognize it as a problem.
2. Understand -
   (a) the factual core of knowledge and concepts involved;
   (b) the complex interaction between the core of rationality; (i.e. the scientifically 'true' facts and

concepts) and 'ideology' - consists of a second layer of technical facts dependent on economic and political power relations (the power to make them 'true'), and of a third layer of myths, beliefs and values as 'facts' (Eliot, 1985).

3. Appreciate the significance and the meaning of various alternative possible solutions (resolutions) to the problem at hand.
4. Capability of exercising the problem-solving act; that is:
   (a) recognize/select the relevant data/information;
   (b) analyze the data/information for its reasonableness, reliability, and validity;
   (c) evaluate the dependability of the resources used and their degree of bias;
   (d) devise/plan appropriate procedures/processes/ strategies for further dealing with the problem.
5. Make and defend appropriate value judgements based on personal values and beliefs systems.
6. Ability and willingness to entertain the decision-making act; that is:
   (a) make rational choice between available alternatives, or generate new options if necessary.
   (b) make a decision or take a position concerning the desirable (and feasible) course of action.
7. Act according to the decision made and take responsibility for this action.

Clearly both problem-solving and decision-making in the context of STES education are different and much more demanding than the 'exercise-solving' process in ordinary disciplinary science education.

Moreover, most states of functional STES literacy summarized in the steps above, require high levels of thinking since our main concern is not the future "technical" problem-solvers (i.e. technicians, engineers, scientists); but rather the future literate citizens. We expect the students exposed to STES education not to solve the "big" problems dealt with but rather to take a position -- based on both their cognitive analysis and value system -- and to act accordingly. Hence, the 'problem-solving act' on the part of the student in the STES education context means choosing between alternatives. The 'decision-making act' involves making a decision and taking the corresponding appropriate course of action. Evaluative responses concerning STES-related issues and not technical solutions are required on the part of STES students (Zoller, 1987), and this distinguishes the PS-DM act in the context of STES education from the corresponding act in the context of traditional science education. This difference in goals is reflected in the difference of emphasis in "classic" science education compared with those of proposed STES education as summarised in Table 1 below.

Table 1. Emphases in "Classic" SE and in STES Education

	Science Education	STES Education
1.	"Knowing" - concerning the state of the art in the disciplinary subject-matter studied.	"Relating to" and "Deciding" concerning pressing inter-disciplinary STES-related problems.
2.	Position is characteristically rationalist, quantitative, abstract, atomistic and static.	Position is inclined to be intuitive, qualitative, concrete, holistic and dynamic.
3.	Emphasis on the theoretical, having general validity at the expense of the practical.	Emphasis on the practical, specific context-bound, at the expense of the theoretical.
4.	Striving for the 'pure' scientific truth (the "right" solution) without concern for practicality and applicability.	Awareness and concern for implied short-and long-term consequences of any applied "best" possible solution.
5.	Using the scientific principles, concepts and conceptual schemes for explaining the universe.	Using the scientific principles, concepts and concept schemes in their applied "technological" sense; i.e., for influencing the direction of change and development.
6.	Dealing with isolated phenomena (and 'problems') from a disciplinary point of view; exact 'neutral'; and impartial analysis of facts.	Dealing with actual problems in their real context; interdisciplinary system approach in analysis.
7.	Only one correct solution is possible for a given problem.	Many resolutions are possible contingent on value-judgement considerations and criteria employed.
8.	Educational-learning goals are academically-oriented,and are dominated by the needs of the science disciplines and scientists *per-se*.	Educational-learning goals are dominated by the needs of society and action is expected outside the domain of science & technology *per-se*.

Given that (a) STES-type problems in our modern technology-dominated world are complicated and multi-dimensional with far-reaching implications; and (b) any decisions about actions must be made under a high degree of uncertainty, the task with which the student 'problem-solver' in STES courses has to cope with is very difficult and highly demanding indeed. Furthermore, since most of the major STES-related problem issues for which the students are expected to seek solutions are "unsolvable" to begin with, it is in a way paradoxical to expect PS capability to develop while addressing unsolvable problems. By the same token, it seems paradoxical to expect a meaningful 'decision-making act' followed by action concerning a 'solution' (or even agreed upon 'desirable state') for which there are no practical ways or established methodologies to the means to achieve it (Zoller, 1987).

Clearly the "translation" of the 'PS and DM act' within STES education into manageable and assessable science curricula and science teaching strategies is not an easy task, but it should be done.

Selected Issues of Concern in STES Education

Recently there is an increased sense of urgency about the effect on our lives of the interaction between science, technology and society. Consequently there is growing support by science educators for the inclusion of an STS emphasis in science teaching (Gaskell, 1982). Thus, STES education can be seen as a timely response to the perceived state of crisis in science education, and in its broader sense can be conceived as: education within the particular local reality of our current socio-techno-political context, about STES, for the science-technology, environment and society, and for the well-being of man and society in our technology-oriented society with so many pressing environmental-societal-political problems.

It follows, that if STES education is expected to respond to the needs of individuals, groups, and democratic societies, it cannot be neutral and cannot any longer be contingent on the particular "needs" of the separated science disciplines *per-se*.

The issue is not the content of STES education, but rather its purpose - perspective, objectives, and expectations as determined by its conceptual framework. This framework would, in turn, determine the different "contents" which best suited different set of local constraints. As STES science educators we have positions (or at least appear to have reached some sort of consensus) concerning major STES-oriented issues. STES education is mission-oriented and, therefore, political because the knowledge, skills, competencies, and the development of ideas within its framework are aimed at achieving active involvement and responsible actions to be taken by the students-citizens. STES is not just another "harmless", intellectual exercise; it is a deliberate attempt to change students from being unconsciously 'automatic' to being consciously-aware of decisions and behaviors in the real world context. Value-laden decisions have to be made and 'no decision' is in fact a very crucial decision with all the consequences of that decision. In the STES domain it is even more so.

In order for the students' decisions to be rational, intelligent, meaningful, and realistic concerning interrelated STES issues, a system-thinking orientation (Schultz, 1983) should be the guiding approach in STES education. Similarly, in order for the personal dimension to be realized within STES education, valuation (i.e. the application of value judgements in dealing with STES-related issues and problems) is an important and legitimate component within the STES PS-DM act. The difficulty in applying these two crucial components - system-thinking approach and the valuation -- can be appreciated if one remembers that both are in contrast to current practices in traditional science teaching. This state of affairs is not surprising: a leading question in traditional science education is - "what is it?" whereas a leading question in STES education is "what are the 'trade offs' and consequences of ... a course of action or an applied technology ?"

Consequences and Applications - The Practical

Some selected consequences which evolve from the above approach to, and treatment of STES education are summarized below followed by a few practical suggestions. These illustrative examples of field-tested STES practices are appropriate for both science and non-science-oriented students at all levels. An important consequence of this approach is that it requires education for problem-solving, not exercise solving (Zoller, 1986) and decision-making for action. It is therefore, more demanding than traditional science education. Through STES education we want to produce not only the future science "technicians" and/or professionals but the active "STES-interpreters" for which the capability of high levels of evaluative thinking in particular is a must. A second consequence is that STES issues and interactions should be dominant organizational constructs of STES courses and curricula. Furthermore, these courses should be interdisciplinary, provide PS-DM situations in dealing with STES issues, and accept *a priori* the multi-solution condition; that is the existence of more than one solution to any real STES problem.

Finally, the role of the science teacher should be changed if STES education is to become meaningful and effective in achieving its goals. The teacher can no longer be the sole "provider" of knowledge who mediates between textbooks and students. Rather, the teacher should play a more guiding and co-learner role, designing a questioning 'learning environment' in relation to STES issues. The response of the students in terms of the PS-DM act will then be based on personal experience, individual and/or group study of problems based upon real world conditions.

Clearly, all of the above consequences have implications for curriculum development, teacher training, classroom implementation and evaluation.

The following are a few illustrative examples of the "translation" of the theoretical into the practical:

(a) Curriculum development: 1. TSAC (Zoller, 1978) 2. IEEP (Zoller, 1986), two curriculum projects for secondary schools.
(b) Teacher training: "Chemistry of Man's Environment in the modern Socio-Technological Context" - a STES pre-service for prospective elementary and junior high school teachers implemented during the academic year 1986/87 at the University of British Columbia, the School of Education.
(c) Teaching strategies and materials: (Zoller, 1984; 1986).
(d) Evaluation of effects of STES courses and of students performance: The Eclectic Examination. (Zoller, 1983a).

The contribution of STES education to both the overall education of our future citizens and the potential impact on the decisions responsible citizens have to make in dealing with controversial societal issues are of utmost importance. The implications concerning the quality of our future life are apparent. A STES education component within the framework of on-going science education is clearly needed. What precise form and direction it should take is, of course, a matter of value judgement within the educational PS-DM act.

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(a) The Pre-University Educational System of Israel:

I. Ages 6 - 12 (Grades 1 - 6): Elementary School.

II. Ages 12 - 15 (Grades 7 - 9): Junior High School.

III. Ages 15 - 18 (Grades 10 - 12): High School.

Modes of assessment used for University entrance:
Weighted average of: 1. matriculation certificate. 2. national psychometric test. 3. special concourse tests (primarily in the physical sciences & mathematics) for entrance into certain schools and/or departments highly on demand (electronics, computers, medicine, law and others).

(b) The submitted paper fits into stages II and III as well as into substantial portion of undergraduate university level. Several aspects are relevant to basic issues in education (science education in particular) at all levels, that is: elementary - to graduate tertiary education.

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1974 - to date: Head of the Division of Chemical Studies, department of science education at Haifa University-Oranim, The School of Education of the Kibbutz Movement in Israel. B.Sc. (Summa Curn Laude) and M.Sc. in Chemistry from the Technion-Haifa, Israel, S.M. (Chemistry) from M.I.T.; Ed.D. (Science Education) from Harvard, 1973; and D.Sc. (Chemistry) - M.I.T. - Technion (1974). 1963 to date: Consultant to Industry and several Government Agencies in the field of synthetic detergents. 1979 - to date: member of the Israel National Committee on Problems of the Environment - The Israel Academy of Science.

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DEVELOPMENT OF A SYLLABUS AND PROGRAM OF AN INTEGRATED STS-CURRICULUM FOR LOWER SECONDARY EDUCATION

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1. The project 'Science for 12-16 year olds'

In the Netherlands the emphasis on STS-education is increasing. In 1973 the PLON started (Project Leerpakket Ontwikkeling Natuurkunde) to develop (until 1986) a complete program for physics for secondary schools, wich can be characterized as a STS-program. In 1982 the Dutch State Department of Education published a discussion paper for a new structure of comprehensive junior secondary education. Among other things it emphasized the impact of science in today's society and proposed an integrated science education -with emphasis on its usefulness in daily life- and 'technology' as a new subject. Since the 70's some schools are experimenting with technology, especially comprehensive schools and schools for lower vocational education. In 1983, 1984 and 1985 State Commissions for the revision of examinations for chemistry, physics and biology published their first reports. The reports stressed the importance of applicable content, societal issues and learning in contexts. The new examinations will be implemented from 1989 onwards.

In the Netherlands there is hardly a tradition in integrated science; only in a few schools an integrated program is offered, although in about 40% of the schools (lower vocational education) there is no formal objection to integrated science. However, in discussions about comprehensive junior secondary education integrated science was proposed, and in a draft bill for the reform of secondary education (published in 1985) about the 'area of experience' 'nature' was mentioned. A few months later the Scientific Advisory Council on Goverment Policy published an advise in which quite the opposite was proposed. Integration of science was not seen as desirable, and a syllabus for science should consist of biology and physics (including some chemistry). This advise was accepted by the Government and incorporated into a new draft bill.

In this changing political context (see also Labordus, 1986) the National Institute for Curriculum Development started in 1982 the project 'Science for 12-16 year olds' (in Dutch: Natuuronderwijs voor 12-16 jarigen, abbreviated as NO 12-16).

Two imported choices were made:

- the choice for one unified subject: Integrated Science;
- the choice to select content based on contexts which have relevance for the student.

The project is concerned with three levels of curriculum development: the national level, the school level and the level of the classroom. The development of themes (units) and program proposals based on a syllabus have been emphasized. The themes have two functions:

1. They give schools the opportunity to use relatively well elaborated teaching materials; in this way schools can contribute to the development of their own science programs.

2. They give an opportunity to the project to concretise didactic choices within teaching materials, thus enabling the project to get a better picture of what is feasible for the ordinary teacher.

In this paper the development of a Syllabus, containing assessment objectives, and a Program Proposal based on it is described. The development of the entire project is described in more extense elsewhere (Boersma, 1986).

In discussions about STS education -as characterized by the position paper of the National Science Teacher Association (NSTA, 1984)- some points can be noticed (see e.g. Bybee, 1985).
1) Relatively much attention is given to societal needs, and less attention is given tot personal needs;
2) Although emphasis is given to the application of science content, the discussion about selection of content is restricted to socio-scientific issues;
3) Hardly any attention is given to the desired sequence of the entire science curriculum; science education is often planned as a collection of independant courses or units.

The Syllabus and Program Proposal of NO 12-16 based on it have to meet the following criteria:
a) Content should be relevant for students; a balance should be found between personal and societal needs.
b) The content should be integrated and not segregated in the traditional science disciplines; it should contain elements from biology, physics, chemistry, geography and agriculture.
c) In the sequence of the Program Proposal a balance should be found between context and conceptual structure.
d) It should be feasible in the time allotted.
The criteria show that emphasis is given to some of the familiar STS issues, and also to the problem of sequencing the content.

In our opinion the selection and sequencing of content (or objectives) are among the main problems in curriculum development, especially when non-traditional problems as selection of content according to the first criterium mentioned above are encountered so that the boundaries of the relevant body of knowledge are uncertain. NO 12-16 faces -as most other STS-curricula- some of these non-traditional problems. For that reason it may be relevant for others to see how we tried to solve those problems of selection and sequencing.

2. Development of the Syllabus and Program Proposal

The selection and sequencing of STS-contents were not two strictly independent phases in the development of the Program Proposal. The Syllabus, based on the goal for science education of the draft bill for comprehensive junior secondary education, was developed between January 1985 and August 1985. The development of the Program Proposal was based on it and lasted until November 1986. On several moments the development of the Program Proposal led to readjustment of the formulations of the Syllabus. An English version of the Syllabus was published (Jozefzoon, 1986).

The Syllabus

The main problem in the development of the Syllabus was how to select content relevant to the student and how a balance could be found between personal and societal needs. Furthermore the content should be integrated and not segrated a priori in the traditional science disciplines.

The problems could not be solved by selection of the most relevant contexts followed by the selection of the most relevant science content within these contexts, because we were not able to determine and agree upon the most relevant contexts. Moreover some trials showed that the selection of science content within a chosen context led to a rather arbitrary choice of science content. However, the alternative, the initial selection of science content was not acceptable either, because that did not garantee that the science content could be used in relevant contexts.

The dilemma was pragmatically solved by designing a matrix, which is in fact a simplified context taxonomy, displaying along one side the roles the students have in society now and in the future and along the other side a listing of systems of which student form a part, the systems being listed so that each preceeding system forms a part of the system that follows (see fig. 1).

	a Individual	b Family/life environment	c Street/neighbourhood	d school/professional circle	e Village/city	f. Holland	g The world
1 The students as part of the natural world							
2 The students as (future) user of the natural world, science and technology							
3 The students as (future) participant in the world of work.							
4 The students as (future) participant in the world of leisure activities, recreation, etc							

Fig. 1. Matrix used to assist selection of subject matter for the Integrated Science Curriculum.

Next members of the project team representing the different disciplines included in the project and who were at the same time involved with the development of the matrix, were asked to select science objectives using the matrix as a basis. While selecting this objectives they were expected to keep in mind current innovative initiatives. This procedure resulted in a total of 121 assessment objectives ordered according to the roles listed in the matrix.
With regard to the problem of balance between personal and societal needs, we argued that introduction of complex global problems is useful only when it can be connected with less complex societal problems, that means problems in the student's own surroundings. Consequently to this choice led to an emphasis on personal needs.

The 121 assessment objectives were included in a draft Syllabus for the entire comprehensive junior secondary education.
Several groups, including the Science Advisory Committees for Curriculum Development, commented on this draft in May 1985. At the same time two discussions, each with approximately 25 experts were held. The experts were drawn from relevant teachers associations, teacher training institutes, the inspectorate, environmental groups, curriculum projects and universities. The written comments and reports of the discussions were analysed and recommendations for modifications were formulated. Most criticism was directed to the matrix-based categories which displayed too little balance in spread over the various categories (the categories "the students as participant in the world of leisure" and "the students as participant in the world of work" contributed hardly any topic). Other, more general modifications of the entire Syllabus implied a restriction of 50 objectives per subject area.
Based on these modifications the whole text was revised and a new structure was designed.
This structure needed to have a strong meta-character because it should incorporate the selected content. A sub-division into different types of systems is obvious because the 'system' concept (and a subdivision into different organizational levels) has a strong meta-feature.
The structure comprises just five categories and per category, one or more sub-categories. The categories are based on a distinction between "natural" and "human" systems. Within "natural" systems a distinction is made between systems at object-level and those at super-object level (e.g. eco-systems). Within "human" systems a differentiation is made between the category "construction" and the category "production". To complete the list, another category was distinguished to incorporate the influence of "construction" and "production" on natural systems at the super-object level.
The structure of the Syllabus for science education is presented in fig. 2.

Subsequently all the assessment objectives were placed under one of these five categories and were later further sub-categorised. Finally the elements were re-formulated so that their number could be reduced to 50.

1. Objects and phenomena
   1.1. A person's own body
   1.2. Plants and animals
   1.3. Materials and matter
   1.4. Phenomena

2. Object and surroundings
   2.1. Surroundings
   2.2. Systems

3. Construction
   3.1. Tools
   3.2. Architecture and use of energy
   3.3. Transportation and communication systems

4. Production
   4.1. Agrarian production
   4.2. Production of materials
   4.3. Energy sources

5. Man, environment and technology

Fig. 2. Structure of the Syllabus for science education.

A revised draft of the structure and assessment objectives was discussed in August 1985 with a group of about ten specialists. All their comments were, as far as possible, incorporated into a final text which appeared in November 1985.

The Program Proposal

Working out the Syllabus to a Program Proposal we met with the problem of finding a balance between context and conceptual structure. Should all science content which is relevant in one context be brought together or should the conceptual structure be maintained? A totally different problem is of course that the Program Proposal should conform to the time allotment.
It was argued that, in order to favor the application of the science content in other contexts than in which it is offered, it was desirable to maintain partly a conceptual structure. Consequently a procedure was developed in which contexts and conceptual structure were interwoven.
Several attempts were made. Members of the project team generated specifications of the assessment objectives, so that we had a more concrete picture in mind of what was ment. Initially it was intended to convert these descriptions into 'concept maps', using the procedures described by Novak & Gowin (1984), and to use the most inclusive concepts of all these concept maps to construct a concept map of higher order. This "macro" concept map should than be seen as the conceptual structure on which, according to the theory of Ausubel (Novak, 1986), a sequence could be based. Next the contexts should be interwoven (see Boersma, 1986).

Nevertheless this procedure was not followed for a number of reasons. First we still felt unsure about the problem how to tackle the proces of the interweaving of contexts and a conceptual structure. Secondly we questioned how sensible it is to base a sequence on the ausubelian assumption that the most inclusive concept of the 'macro'concept map should be introduced as early as possible. We preferred the following criteria for sequencing:

a) towards increasing complexity (i.e. organizational level), starting from the object level;
b) application of concepts after their introduction;
These criteria can be seen as examples of the next criterium:
c) establisment of prerequisite knowledge.

Finally a procedure was worked out; this procedure will now be described step by step.

1) After elaboration of all assessment objectives the scientific key concepts were selected. It appeared that most scientific concepts were linked to chapter 1 and 2 of the Syllabus (Objects and Phenomena, Object and Surroundings). This analysis showed that the various chapters of the Syllabus corresponded closely with Science, Technology and Society. In chapter 1 and 2 (see above) the scientific content -within various relevant contexts- is offered, while chapter 3 and 4 (Construction, Production) offer the meaning of the scientific content in technological contexts, and chapter 5 (Man, Environment and Technology) offers the meaning of scientific content and technology in societal issues. The analysis led to some appositions of the Syllabus.

2) Next the key concepts were used to construct a learning structure, showing prerequisite relations among the concepts (Reigeluth et al. 1981) (see fig. 3).
Since this learning structure only consists of concepts, it may be called a conceptual learning structure. The problem was of course how to differentiate this conceptual learning structure into parts which contain the most important prerequisite relations. In fig. 3 these parts of the conceptual learning structure are indicated. Each of this sub-structures is prerequisite to one or more other sub-structures or to assessment objectives of the chapters 3 to 5 where the same science concepts were used in technological and societal contexts. Fig. 4 shows the prerequisite relations between the concept learning structure -figured in sub-structures- and the assessment objectives of the chapters 3 to 5.

3) Although many of the assessment objectives were formulated in such a way that a rough indication of a relevant context was included, it was felt that the problem of interweaving concepts and contexts was not adequatly solved. Therefore we readjusted and elaborated the matrix which was used for the selection of relevant assessment objectives (see fig. 1) in such a way that the roles people play in society were reformulated and divided in different "context areas" (see fig. 5).

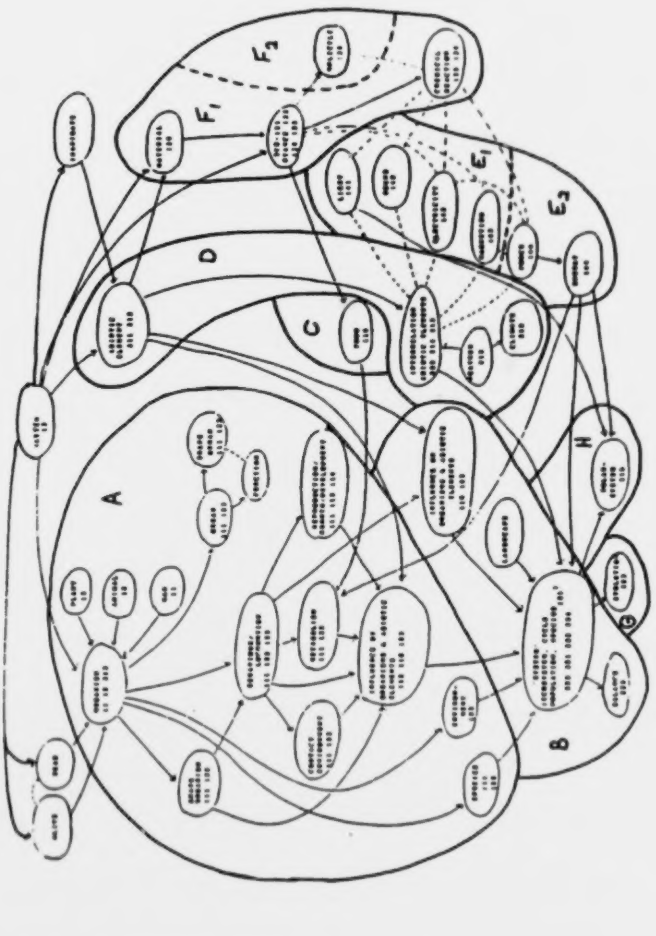

Fig. 3. The conceptual learning structure. The arrows indicate prerequisite relations. The dotted lines indicate meanigful relations. The areas A to H indicate the sub-structures which were distinguished. The numbers below the concept name indicate the assessment objectives of the Syllabus in which the concept is first mentioned.

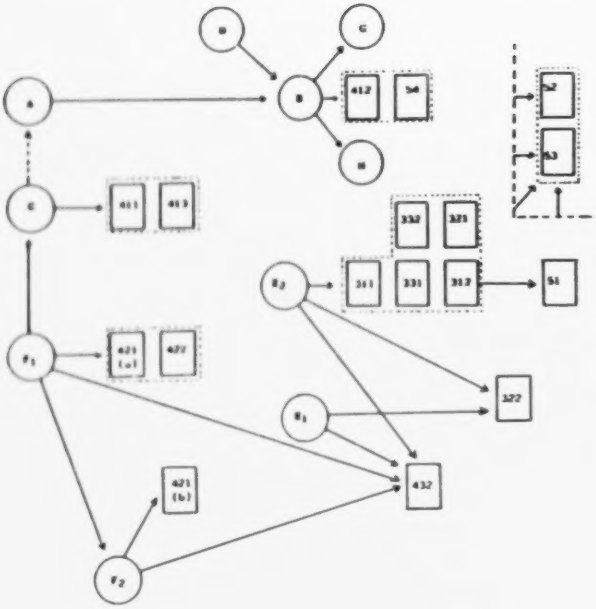

Fig. 4. Learning structure consisting of the conceptual learning structure (figured in the sub-structures A to H) and the assessment objectives of the chapters 3 to 5 of the Syllabus. Assessment objectives 5.2. and 5.3. are to be considered as a synthesis: all other objectives are prerequisite. The dashed lines around several assessment objectives indicate that no prerequisite relations are supposed.

Next all assessment objectives were placed in this context matrix. Some context areas which hardly contained assessment objectives were skipped since the content elements they contained could also be connected with other context areas. Identical or resembling context areas which appeared in different roles (e.g. food and feeding) were also taken together. In this way the number of context areas was reduced from 20 to 11. Since the reduced context matrix contained all assessment objectives (except two that had solely a scientific content), and since the relations between the

Role ('man as')	Context area	Dimension				
		[illegible]	[illegible]	local/regional	national	global
A. Protector of the own body	1 Health					
	2 Feeding					
	3 Shelter					
	4 Cosmetics					
B. Partner	5 Communication					
	6 Sexuality					
C. Protector of the other	7 Fellow-man					
	8 Plants and animals					
	9 Environment					
D. Consumer	10 Tools and objects					
	11 Food					
	12 Public utilities					
	13 Means of communication					
	14 Traffic					
E. Producer	15 Food					
	16 Materials					
	17 Energy					
F. Decision maker	18 Providing (A - C)					
	19 Consumption (D)					
	20 Production (E)					

Fig. 5. Context matrix in which all assessment objectives were placed.

assessment objectives were elaborated in a learning structure (see fig. 3), concepts and contexts were actually interwoven. Now the 11 context areas could be summarized.

4) The last step was to transform the learning structure to a Program Proposal. For that purpose it was necessary to make additional decisions, especially about some practical restrictions.
First the number of lessons which could be used for science education was taken in consideration: 3 x 40 lessons for 2 years. Since the Syllabus was developed for 8 x 40 lessons for 3 years the most inclusive concepts (and the assessment objectives for which these concepts are prerequisite) were reserved for the 3d year.
Secondly the 11 context areas were weighted; each one was attributed with a factor 1, 2 or 3. In this way the number of lessons available for each context area could be estimated.
Considering the learning structure two additional decisions were made in an early phase. First the relevant skills (instrumental, problem solving and communicative skills) were connected to the assessment objectives in such a way that the skills were connected with relevant contexts and concepts. This was not seen as a very complicated curriculum problem since it seemed that there were much more useful connections than time available. The second decision was -in accordance with the choice for more emphasis on personal needs and less on societal needs- to sequence the Program Proposal from 'close' to 'distant'.

5. At the moment the Program Proposal is discussed in the project schools. The discussion is directed to the feasibility and desirability of the Proposal. Specially the eleborations of the assessment objectives enable a detailed comparision between the Proposal and the actual science program.

Next year some parts of the Program will be further developed in teaching materials, so that an empirical basis is at least partly available. Taking in account the experiences and comments of schools and others, taking also in consideration the assessment objectives of a national syllabus which will be established by then, the Program Proposal will be readjusted and published.

3. Discussion

The procedure described above leads to a learning structure which can be readopted and elaborated to different Programs. We also believe that the learning structure can be readopted to discipline oriented science education, a situation which may be reestablished in the near feature in the Netherlands.
In spite of the flexibility of the learning structure we still see some unsolved problems.
First the learning structure does not include technological and social scientific concepts. It was supposed that these concepts would be available and that an introduction in science education would be unnessessary. This presupposition may be partly erroneous. That shows the problem that for a complete learning structure for STS-education the connection between science education, social science education and technology education has to be worked out.
Secondly sequences of problem solving and communicative skills were not elaborated. We believed that the eleboration of skills in learning activities is mainly determined by the concepts and context of the learning activity, and that an independent sequence showing increasing complexity is not to the point.
May be a fundamental choice should be made in favor of sequencing skills to the detriment of sequencing concepts or vice versa.
That leads us to a third unsolved problem. The learning structure consists of science concepts, skills and contexts, and includes no meta-knowledge and meta-skills (see e.g. Aikenhead, 1980).
Nevertheless we are convinced of the importance of meta-learning (see e.g. Novak & Gowin, 1984) and of education about science (Barrentine, 1986).
One mayor point was not solved in the Program Proposal: the feasibility of the time allotment. In spite of their own teaching experience curriculum developers find it very difficult to make a sound estimation of what is possible. Empirical evidence is urgently needed. The project NO 12-16 did not have the possibility for an extensive empirical validation. Keeping this in mind we expect a lack of feasibility in the current Proposal. Comments of the teachers of the project schools are indispensible for the reconstruction of the Proposal. The definite Program Proposal will be published in 1988.
In the reconstruction of the Program Proposal other selection criteria then have to be used. Especially when meta-learning and education about science have to be incorporated, we come close to a point where a fundamental choice has to be made. Either a STS-program with emphasis on science content, or a STS-program with emphasis on the role of science in our society (see Aikenhead & Fleming, 1975). And may be students are learning more when less science content and more meta-learning is incorporated.

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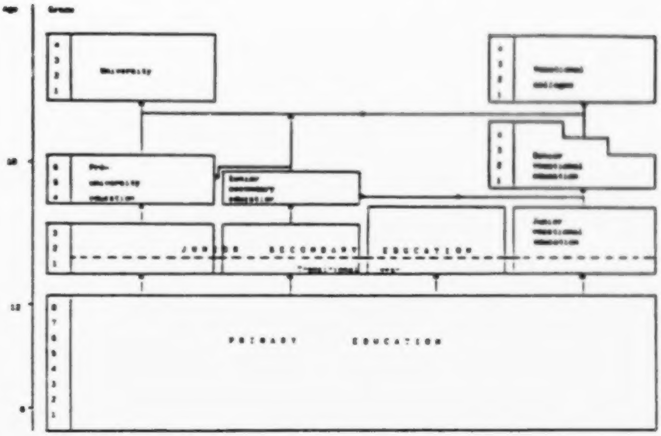
The Dutch educational system


Age
Grade
University
Vocational colleges
18
Pre-university education
Senior secondary education
Senior vocational education
Junior vocational education
JUNIOR SECONDARY EDUCATION
Transitional year
12
PRIMARY EDUCATION
6

Simplified overview of the actual Dutch educational system. Only students who pass examens of pré-university education are admitted to the university.

The project presented in this paper is concerned with junior secondary education.

Kerst Th. Boersma (1943) studied geology and did his PhD (1973) at the University of Leiden. The next years he worked as science publisher at an educational publishing company. In 1975 he moved to the Pedagogical - Didactical Institute for teacher training of the University of Utrecht, where he worked specialy on the development and implementation of courses for biology students. Since 1984 he works as head of the science department at the Dutch National Institute for Curriculum Development (SLO) at Enschede.

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INDUSTRIAL CHEMISTRY AS A METHOD TO TEACH THE LINK BETWEEN SCIENCE, SOCIETY AND TECHNOLOGY

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1. Introduction: Does our Chemistry curricula reflect the spirit of time?

In an article titled "Is school chemistry relevant", Barbara Presst in the U.K. wrote:
"*Looking at a school chemistry syllabus, it is difficult to realize that we live in a world which is increasingly dependent on the work of a chemist. School chemistry courses show almost no sign for the change which has taken place in the last few decades for present day needs there are completely irrelevant*" (Presst, 1970).

It seems that since then very little has been accomplished in this area since in his 1983 lecture at Montpellier during the 7th ICCE Prof. Kempa called for the development of an effective 'Chemical curricula and courses' he wrote: "*... The courses and curricula should adequately reflect the spirit of the time as well as being educationally effective*" (Kempa, 1983).
Does our chemistry curricula reflect the spirit of the time?
In reviewing the school chemistry curricula in use around the world one arrives at conclusion that in the 80's we still go on ignoring one of the most important and influential component of our everyday life, namely the Chemical Industry.

Almost all the secondary science curricula developed throughout the western world during the golden-age of curriculum reform (1960-70) were based on the conceptual structure of the discipline. They tried to show how a chemist works in a research laboratory, emphasizing laboratory work and concept formation and usually did not attempt to include any technological or societal applications of the scientific concepts studied. The developers of the 'new' science curricula considered technology to be at best irrelevant and, at worst, an interruption in the order of development of the structure of the science being studied.

The teaching of chemistry without discussing the various aspects of chemical industry omits one of the most important features of modern life. One result of this omission is the overemphasis in the media of the hazards of pollution, waste disposal and other environmental disasters. These phenomena are indeed part of the facts and problems of daily life but the publicity they attract gives unbalanced picture of the nature of science in general, and of chemistry in particular.

2. The Implementation of Industrial chemistry learning units: Problems and Successes

During the last fifteen years many articles were written about the need to incorporate aspects of industrial chemistry into the regular chemistry curriculum.
Why is it, however, that although so many called for redefining and reformulating the goals of science teaching to the needs of society so little has been done?
In order to examine the difficulties in the development and implementation of industrial units, it is important firstly to define the goals of such learning units. My view is that the goals of such learning units should be:
i. To consider the basic chemical principles as applied to the production of chemicals on an industrial scale;
ii. To demonstate the importance of the chemical industry to society and to the economy;
iii. To develop a basic knowledge of the technological, economic and environmental factors involved in the establishment of a particular chemical industry;
iv. To investigate some of the specific problems faced by the local chemical industry e.g. location of industrial plant, supply of raw material, labor, etc.
What are the problems in attaining these goals?

a. The problem of the teacher
The main difficulty in the implementation of an industrial chemistry learning unit is no doubt the chemistry teacher. The traditional training of a chemistry teacher at the university or teacher training college level hardly ever touches upon the applications of chemistry in general, and upon industrial chemistry in particular. Another difficulty is that in most cases up to date information on industrial chemistry is not readily available to the teacher. Because of this, teachers are unsecure to discuss with their students, the economic technological and environmental issues of a chemical plant. Teachers do not feel competent to handle the many facets that such an interdisciplinary program touch upon.

b. The influence of universities and external examination boards.
Although university academics and administrations give verbal expression to the importance of programs which incorporate industrial applications, their entrance requirement and the requirements of the external examinations, are geared to the conceptual structure of the discipline. There must be more than verbal commitment on the part of the universities and examination boards to the value of such a course like chemical industry. Only then will such courses have a chance to make a significant impact on the chemistry school curriculum.

c. The local industry
The successful development and implementation of a course on industrial chemistry requires the active cooperation and if possible, the participation of the chemical industry itself. The support of the local industry is important both in the development stage of a course as well as during implementation in schools. This cooperation& support is important for the organisation of visits in the industrial plant, replies to teachers inquiries, supply of lecturers

for schools and in the design and preparation of teaching aids (e.g. films, slides, booklets about industry, etc.). Creating an active link between schools and industry is an important aspect of the implementation of such courses.

3. The Development of a Learning Unit in Chemical Industry

Over the past 15 years, few attempts have been made to introduce material about the chemical industry into the school chemistry curricula.

In Scotland, for example, Johnstone and Reid (1979) developed the "Amsyn Problem"; in which the student is involved in the study of relevant scienceand in the application of scientific knowledge. The student participates in simulated resolution of relevant science problem. Case studies in industrial chemistry were developed by the J.M.B. (1974) in the U.K. to be used as part of the A-level syllabus.

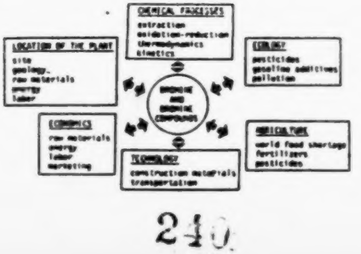
In Israel, we (Nae, Hofstein and Samuel, 1980) have developed a unit that is used with 12th grade students (age 17) that consists of three case studies on the chemical industry. The list of goals that were mentioned above were used as an organiser to the development of these case studies.

I wish to elaborate a little on one of the case studies namely the one that is called "*Life from the Dead Sea*".

The central theme of this case study is the production of bromine and bromine compounds. The case study begins with a discussion of the geography of the Dead Sea, its mineral content (330 mg/dm^3) of magnesium sodium and potassium chlorides and bromides. This is followed by a discussion of the world food shortage, the need for fertilizers, and the role played by the production of potash by the evaporation of the dead sea brines. How these issues relate to the Dead Sea is "brought home" by specifically considering bromine. Bromine is produced at the Dead Sea from the bromides in the "end brines" of a potash plant. These solutions contain about 12 g of bromide ion (Br^-) per liter, totalling about 350,000 tons of bromine available for extraction each year. The students soon realize that the benefits of extracting bromine from the Dead Sea may have worldwide application since bromide compounds are widely used both as pesticides (methyl bromide) in agriculture, and as additives in gasoline (dibromethane).

In order to discuss how bromine can be extracted from bromide solutions, the students in the laboratory, compare the various ways of producing bromine by (i) electrolysis of brines, (ii) reaction of bromide ions with chlorine and (iii) 'oxidation' of sodium bromide with potassium permanganate. Students discuss the production and uses of such compounds as dibromoethane and methylene bromide. Finally, with data supplied to them, determine the availability and cost of the raw materials, the energy needed, the safe disposal of by-products, and technical and economic problems involved in scaling up to full production. Students also simulate the process of decision making in a discussion and analysis of the factors relevant to deciding on the location of a new plant for producingbromine and bromine compound.

Figure 1 illustrates the overall components of the interdisciplinary approach of the bromine and bromine compounds case study.


CHEMICAL PROCESSES
extraction
oxidation-reduction
thermodynamics
kinetics
LOCATION OF THE PLANT
site
geology
raw materials
energy
labor
ECOLOGY
pesticides
gasoline additives
pollution
BROMINE AND BROMINE COMPOUNDS
ECONOMICS
raw materials
energy
labor
marketing
AGRICULTURE
world food shortage
fertilizers
pesticides
TECHNOLOGY
construction materials
transportation

4. The training of teachers to teach the industrial case studies

As was mentioned above, the main problem in the implementation of industrial courses is the lack in preparation of high school chemistry teachers. In order to overcome this problem, a series of in-service teachers courses were held at the Weizmann Institute of Science, for teachers intending to teach this course. These included (a) one day conference on chemical industry in general, with lectures (on the industry of fertilizers, pharmaceticals and plastics) from experts in the fields, (b) eight lectures by chemists from some of the major chemical industries and visits to some of these industries, such as the Dead Sea potash and bromine works and to the heavy chemical industries (ammonia, nitrates, detergents, plastics) round Haifa bay, and (c) a four day in-service training course, specifically designed for teachers who were going to teach the new unit. In this course, each case study was discussed in depth, the experiments were tested in the laboratory, and various administrative and didactic problems were discussed. During the preparation of this course, contacts were established with many of the local industries which helped to provide some financial support for the project and in organizing visits (Nae and Hofstein, 1983).

Another aspect which is worth mentioning is that in recent years it has been suggested that teachers themselves should become more involved in the process of curriculum development and implementation (Sabar, 1983). In fact, the idea is that the teacher will become the developer of substantial part of the science curriculum he/she is implementing in his/her classroom. Recently, we made an attempt to train teachers to develop their own industrial case studies. We organized a longitudinal inservice course for senior chemistry teachers. The teacher came one day a week during the academic year and were trained in improvement of instruction, scientific subject matter as well as didactics of chemistry. At the end of the course teachers, in groups, were asked to prepare a final project - a case study in the chemical industry. In these case studies, teachers were asked to use variety of instructional methods to which they were exposed during the course. Teachers made contact with different industries, developed the story board of the industrial plant, suggested learning activities and experiments to simulate the industrial process. Information about technological, economical and environmental issues concerning the plant was provided.

The following case studies were developed:
- The soap and detergents industries.
- The industrial production of MgO - (a raw material used in high temperature bricks for furnaces.)
- Chemical fibers for the textile & related industries.
- The batteries industry.
- The manufacture of rubber tyres.

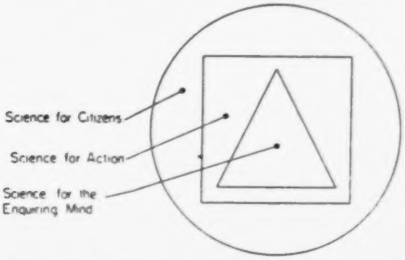
Similarly the science education group, at the university of York has involved a group of scientists, secondary school teachers and chemists from industry and university in the development of the A'level Chemistry Curriculum which cover industrially based topics (see for example Waddington and Nicolson (1985).

5. Application to other countries and other curricula

In all countries, there is a need to open a window to the "real world" outside the school. I am sure that the chemical industry can provide an interesting and useful opportunity for introducing relevant issues to pupils in senior high schools. The guidelines in planning such a course are the same in most countries, even though obviously the actual industries described and the details of the methods of production vary from place to place. Each case study should be chosen using the criteria described, keeping in mind the importance of that particular industry to the country in question.

In some countries it might not be possible to add a full course to the existing curriculum. In these countries there is merit to using the 'case studies' method, which allows the teacher, or the examining board, to incorporate one or more case studies as a part of the curricula, according to the time available.

The teacher could use the model suggested by Lewis (1980) for the design of science curricula. Lewis suggested that in the future, learning units in science should be made up of three components: "science for the inquiring mind, science for action and science for citizens" (figure 2).



An example of such a unit is the course developed on the chemistry of Fertilizers (Hofstein, 1979). The scientific component (science for the inquiring mind) curriculum is the production of NH_3 by the Haber process:

$$N_{2(g)} + 3H_{2(g)} \quad 2NH_{3(g)}$$

The 'action' dimension is the technological industrial application of the process and the 'citizens' dimension is the production of nitrogen fertilizers for growing better crop for the overpopulated world as well as some environmental - ecological considerations.

It is suggested that Lewis' model could help for future development of industrial learning units.

Though the chemical industry in different countries is based on different raw materials, an interdisciplinary approach can be used to enable the student to understand the overall concept of the industrial endeavor, to combine chemical principles with problems of technology and economics and to foster a positive attitude to the preservation of the environment.

In conclusion let me mention a recent call to redefine and reformulate the goals of science education. Project synthesis, a comprehensive research project conducted in the U.S. (Harms and Yager, 1981) considered current needs and corrective actions in science education. Four goals clusters divided learning outcomes into categories of relevance:

(a) Personal needs: Science education should prepare individuals to utilize science for improving their own lives and for coping with an increasingly technological world.

(b) Societal issues: Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.

(c) Career awareness: Science education should give all students an awareness of the nature and scope of a wide variety of science- and technology-related careers open to students of varying aptitudes and interests.

(d) Academic Preparation: Science education should allow students who are likely to pursue science academically as well as profesionally to acquire the academic knowledge appropriate to their needs.

Programs on industrial chemistry topics which are based on the interdisciplinary approach described in this paper have the potential in enabling students to attain, at least partially these four goals.

5. Summary

I believe that given a proper training, the average chemistry teacher can develop and teach a course concerning a local industrial plants. In order to do so it is our duty to:

1. provide the chemistry teacher with certain flexibility of time, and of course budget so that they will be able to select the most relevant industrial issues for their students.
2. create active cooperation with local industries which will provide teachers and curriculum developers with relevant information and will help in organizing visits to chemical plants.
3. convince boards of examination as well as universities of the importance of teaching about the industrial chemistry in a broader sense.
4. We, chemical educators and teachers must convince ourselves that as Gallagher stated:

> "*For future citizens in a democratic society, understanding the interrelations of science, technology and society may be as important as understanding the concepts and process of science*" (1971).

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About the Author

The author is the Coordinating Inspector for High School Chemistry at the Israeli Ministry of Education and Culture in Jerusalem, as well as senior member of the Chemistry Group of the Department of Science Teaching at the Weizmann Institute of Science. At the last 20 years he has been involved in chemistry curriculum development, implementation (including teachers' training) and evaluation. In evaluation he is interested in the area of students' learning difficulties, students' performance in the chemistry laboratory workand affective outcomes of chemistry instruction. He has published about 50 papers in professional journals.

Science Instruction in the Israeli Educational System

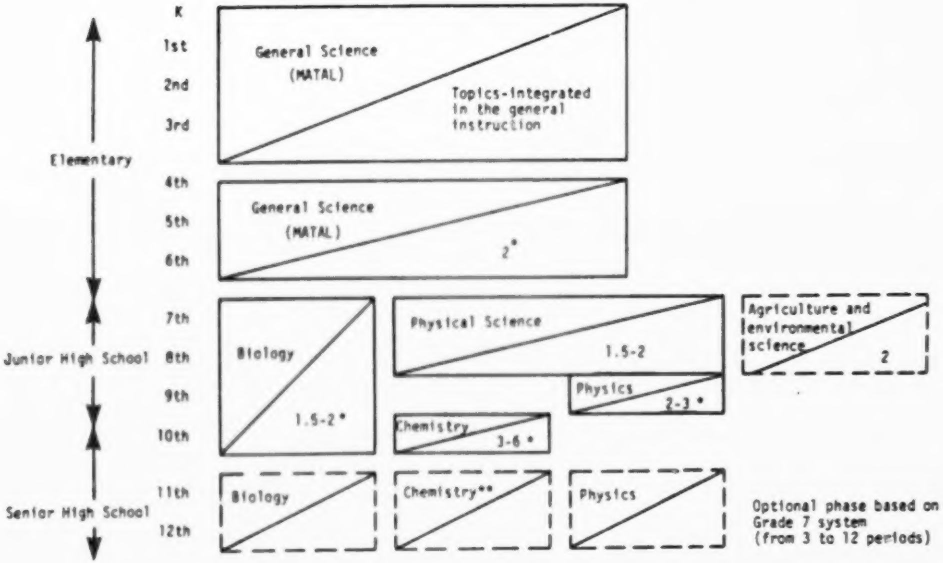
K
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
10th
11th
12th
Elementary
Junior High School
Senior High School
General Science
(MATAL)
Topics-integrated in the general instruction
General Science
(MATAL)
2*
Biology
1.5-2 *
Physical Science
1.5-2
Agriculture and environmental science
2
Physics
2-3 *
Chemistry
3-6 *
Biology
Chemistry**
Physics
Optional phase based on Grade 7 system (from 3 to 12 periods)

Figure 1: Science teaching in Israel - grades K-12

* periods per week.

** Where the case studies on the chemical industry are taught.

THE POTENTIALS OF A SCIENCE TECHNOLOGY AND SOCIETY (STS) COURSE IN A DEVELOPING COUNTRY - THE NIGERIAN EXPERIENCE

Dr. Olugbemiro J. Jegede (Science Education Section; Faculty of Education, Ahmadu Bello University; Zaria, Nigeria)

Introduction

The persistence, till date, of the Baconian climate of using science for the 'merit and emolument of man' which emerged in the seventeenth century has in part been a catalyst for the greater pursuit and use of science and technology in the prevailing times. The focus today has shifted from propagating the influence of science and technology on human life to exploring ways and means of manipulating them to the maximum benefits of society with particular reference to qualitative life.

Nations, worldwide, commit or seek to commit all resources for total national development through science and technology. It is a known fact that scientific and technological activities have contributed, more than any other factor, to the growth and development of countries that have recognised and used them (UNESCO, 1983; Brooks, 1978; Hummel, 1977; Dixon, 1973). The journey from past to present has not been that smooth. The idealist view of science being curiosity-oriented dedicated purely for the unravelling of knowledge irrespective of its applications and moral or ethical issues had a stiff opposition. This opposition came from the mission or utilitarian-oriented view of science in which the pursuit of knowledge is seen as an instrument for gaining total and practical dominance over nature to the benefit of mankind. The esoteric view of science therefore had no place in the scheme of mission oriented science.

The coexistence of the two views - basically science and technology - became real and enforced during the era of the Manhattan project. This led to the increase in budgetary allocations by developed countries to science with a view to utilizing its products for both beneficial and destructive ends in the society (Dixon, 1973). It should be noted that the boost that science education has received within the past few decades was essentially a reaction to the 1957 Sputnik feat. The inclusion of science in the school curriculum as a part of general education has been succintly justified by the Association for Science Education as the need to:

(i) acquire a knowledge and understanding of a range of scientific concepts;

(ii) acquire a range of cognitive and psychomotor skills and processes; and

(iii) utilize scientific knowledge and processes to solve practical problems and to communicate that experience to others.

The zeal to train scientists in the post-Sputnik era although led to a significant departure from the traditional conception of science and its teaching overlooked to certain degree the vocational aspects of it. And yet science education is basically a preparation towards some specific technological or technical careers as well as an understanding of the technical society. Since many students of science study to become engineers, doctors, nurses, industrial managers etc., it therefore made good sense to include in their training some aspects of technology education (Ziman, 1980; Stonier, 1983; Jones, 1982). This marked the beginning of technology education and its distinction from science education.

Science and its application is a human activity carried out by scientists, it is part of man's culture and a social institution used to transform the society. Science is seen as very central to human existence with much emphasis on its cultural and utility values. Besides, scientists are now more than ever before engaged in problems that are social in nature and are determined by society. These underlie the need to present science (and technology) in a totally new package in an effort to making sure that society fully benefits from its knowledge, conception and practice. As reported by Marthorpe (1982), Crowther in 1959 did list the aims of teaching science to those who may not wish to specialise in science and technology as (i) ensuring that people understand the impact of science and technology on society; (ii) ensuring that every citizen should be able to use the fruit of technology and (iii) coping with a world chracterised by rapid change as a result of the impact of technology.

In the contemporary times the issue has gone beyond just teaching science to those who may not wish to specialise in science and technology to making sure every living soul receives the message. Indeed the shift now has been teaching and designing science curricula that are more socially relevant (McConnell, 1982; Fensham, 1985; Hurd, 1985; Aikenhead, 1985; Garrard, 1986) and have justification from the most diversified background that ranged from politics and economics to sociology and philosophy. According to Ziman (1980) and Yager (1985) these new curricular which go by different names (we shall use the STS nomenclature for the purpose of this paper, its all embracing nature and its popularity) have as their fundamental objective the 'correction of the onesided presentation of science and technology as well as broaden the background of students of science and technology, and to prepare them better for their lives as professional workers and as responsible citizens.'

The beginning of this decade has witnessed the start of a forment that seems to have greater capacity, acceptability and durability than any movement/curriculum that has ever been. The STS also has changed considerably the dynamics of the scientific community world-wide.

The STS Course in Nigeria

Its Conception

The advent of science and technology in the developing countries followed a common pattern arising from the influence of colonization and subsequent reforms in their educational system (Jegede, 1986). Just like any developing country, Nigeria's practice of science and technology cannot be compared with what obtains in the developed world. However, the influence of science and technology is greatly felt. The products of science play very vital roles in the daily life of people. The society's effort do develop a scientific culture and focus on science and technological innovations has not matched the rapidity with which the products of science and technology are consumed. Although the influence of science and technology is faintly recognised generally and the few involved in the field attempt to discuss it, there is however no concerted effort to educate the public about the social consequences of science and technology.

Viewed from a different perspective no greater need (educationally) is felt in a developing country heavily bombarded with the products of science and technology (but with low level science and technology activities), than for all its people to become fully aware of the social implications of science and technology. This has been the motivating factor in the introduction of a course Science and Society at the Ahmadu Bello University, Zaria. A course in technology just as we have in science at the junior secondary school is being implemented. At the senior secondary school level the introduction of a course on science, technology and society is desirable. But the decisions and governmental response to all these are often taken at the Ministry level where in most cases officers not very well informed about or interested in projects kill them by their actions or otherwise. It was therefore justified that to be more effective at motivating those that matter in the system, the Science and Society course be introduced at the postgraduate level in universities and other higher institutions where those that are directly concerned with the implementation and formulation of government policies go to study. In addition it serves to inform and prepare science teachers, who come for their postgraduate training, for more effective teaching of science and the incorporation of the social aspects of science and technology in their lessons when back on the job.

At the moment the Ahmadu Bello University, Zaria is the only University in Nigeria that offers the Science and Society course at the M.Ed level. The course which began in October, 1981 derived its aims and objectives and motivation from the U.K. Science in Society and the SISCON courses. The British Councils International Workshop (course No. 428) on Science, Education and Society of July/August, 1984 held at Bradford in the U.K. in which I participated also helped in the evaluation of the course and providing a re-assuring impetus for its continuation. According to Lewis (1979) who is one of the great proponents of the STS course, the 'major problems of the world-energy, mineral resources, population, health etc., - are issues which will dominate the lives of the children we are educating. All these themes have a strong scientific component and a greater awareness of them should therefore be included in the science education we provide for younger people'.

The Science and Society course at Ahmadu Bello University is not a hard core science but a mixture of scientific issues in a sociological setting that tries to portray how modern thinking sees science from the point of view of social relevance. It provides an avenue for people to discuss very freely issues that affect the daily lives of everyone in the country.

Content

The content of the course consists of topics like science in the service of man, scientific literacy, the social dimension of science pollution, transfer of technology and the developing countries, science and politics, science and war, living in a post-industrial society, science as a social institution, computer and science education to mention but a few.

Evaluation

In its six-year existence the course has the highest acceptance among all M.Ed courses by all the 41 students who have taken it. It has among other things (i) developed a lot of interest and enthusiasm towards the problems and benefits of science and technology (ii) been of immense value to curriculum developers, educational administrators, science educators and teachers, sociologists, and others who have attended the course and who would in the near future be faced with the development of or and implement policy decisions about a similar course at the secondary school level in Nigeria; (iii) exposed students to a new thinking in the understanding and teaching of science as well as the dynamics of a scientific community.

The Future

Just like the integrated science movement, the STS needs to assert its presence as a more valid way of looking at the interaction between science, technology and society. It needs to create more awareness world-wide possibly with the assistance of global bodies like UNESCO with a view to making sure that it is a part of the school curriculum. Before these, however, the STS needs to have resolved issues like :

(i) globally acceptable nomenclature

(ii) establishing the foundational structure of the STS;

(iii) determining its basic curricular and instructional structures in schools as well as determining which of the 'S' in STS gets the emphasis;

(iv) training of teachers - in whatever form - to handle the course;

(v) creating an outlet globally for inclusion in all literacy programmes.

For our parts in Nigeria and particularly at Ahmadu Bello University the hope is that the Science and Society course will (a) soon be a University-wide course at least as an elective; (b) have a diffusion effect to percolate to lower levels of education; and (c) in due course be nationally accepted as part of the school curriculum.

Conclusion

Teaching and creating an awareness of the social functions of science in a developing country is an uphill task. But the exciting experience at Ahmadu Bello University seems to indicate that the future has a lot of prospect.

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Pre-University Education in Nigeria

(a) The pre-University educational system of Nigeria has made a transition lately from the British to the American model of schooling. The country now operates a 6 year primary school (approximate school leaving age of 12), 3 year Junior Secondary School (approximate graduating age of 16) and 3 year Senior Secondary School (approximate graduating age of 19). The 4 year University education draws undergraduates through a national matriculation examination, while candidates with qualifications like A-Level, IJMB, NCE, ND enter at appropriate levels.

(b) The paper preared for this symposium fits into the University bracket of the Nigerian educational system.

(c) Autobiographical Notes: Dr. Olugbemiro Jegede is the Head of Science Education Division and the Assistant Dean (undergraduate) at the Faculty of Education, Ahmadu Bello University, Zaria. He holds a B.Sc. (Ed); M.Ed (Sc. Educ); from Ahmadu Bello University, Zaria and Ph.D (Science Educ.) from the University College, Cardiff, Wales, U.K. His occupational experiences include being a Science Instructor at the Nigerian Military School (1972) and the Editor of the Ahmadu Bello University from 1976 to 1977. He was the National Vice-President of the Science Teachers' Association of Nigeria (STAN) from 1982 to 1985. The course 'Science and Society' being taught at the Masters' degree level at the Faculty of Education, Ahmadu Bello University, was designed and introduced by Dr. Jegede in October 1981. He is the author of several books and articles which include Primary Science Teaching (Macmillan, 1980); Tropical Biology: A Practical Course (Macmillan), 1982) and co-authored A New Integrated Science Course (Macmillan, 1986).

THE SCIENCE TECHNOLOGY SOCIETY COMPONENTS IN THE ONTARIO SCIENCE CURRICULUM FOR THE 80'S

Prof. H. Dene Webber (Canada)

The Ontario Science Curriculum has been undergoing a massive revision since 1982. It is in its final developmental stages at the present time and will be implemented in total into the public school system from grades 7 to 13 (Ontario Academic Courses - OAC's) between now and September 1990.

The curriculum guideline developed consists of 15 parts. It outlines in detail the expectations of the Ministry of Education for the development and implementation of science courses in the Intermediate and Senior Divisions of our public school system in the Province of Ontario. Part I of this document sets the stage for the science program; it establishes the framework within which all of the science courses described are to be taught. The course descriptions include specific subject matter, while part I prescribes other complementary components that are essential to the science courses (goals and aims of education and the role of science in the curriculum, the science student in our schools, language in science, measurement, safety, values in science education, aspects of implementation-curriculum planning and staff development, necessary resources, program delivery and evaluation procedures). In designing and implementing science courses at the local level, these components must be blended with the subject matter outlined in the course descriptions.

This renewal of the curriculum in science programs for grades 7 to 12 and the Ontario Academic Courses has resulted in the development of 27 new science courses for implementation. The courses to be offered at each grade level are outlined in Table 1.

Science programs are to be designed to meet definite expectations. Such expectations include the acquisition and application of knowledge in the content of science and the development and application of skills in the process of science. Attitudinal objectives are to be woven into the fabric of the knowledge and skill objectives to emphasize the fact that science is a human endeavour. All of these objectives must be integrated into the subject matter of the science courses designed in order to provide a proper emphasis among the affective, psychomotor and cognitive domains of learning and to relate science to the needs and issues of living. Effectively designed science courses, then, must include what the student is to feel, to do and to know. Invariably, these three thrusts, feeling, doing and knowing, if well balanced in the courses, require consideration of scientific technological applications and societal implications.

One of the major purposes of education is to assist students in becoming effective citizens who can understand and intelligently consider issues which confront society. Science education plays an important role in achieving this goal. Many of to-day's most difficult societal issues are related to the use of science in modifying basic conditions of life and shaping the future.

TABLE 1

Authorized Science Guideline Courses, Intermediate and Senior Divisions

Grade 7	Science				Grade 7
Grade 8	Science				Grade 8
	Basic Level	General Level	Advanced Level		
Grade 9	Science (SNC 1B)	Science (SNC 1G)	Science (SNC 1A)		Grade 9
Grade 10	Science (SNC 2B)	Science (SNC 2G) Environmental Science (SEN 2G)	Science (SNC 2A) Environmental Science (SEN 2A)		Grade 10
Grade 11	Science (SNC 3B)	Applied Biology (SBA 3G) Applied Chemistry (SCA 3G) Environmental Science (SEN 3G)	Biology (SBI 3A) Chemistry (SCH 3A)	Any one of these	Grade 11
Grade 12	Science (SNC 4B)	Applied Physics (SPA 4G) Environmental Science (SEN 4G) Technological Science (STE 4G)	Environmental Science (SEN 4A) Geology (SGE 4A) Physics (SPH 4A)		Grade 12
OAC			Biology (SBI 0A) ← Chemistry (SCH 0A) ← Physics (SPH 0A) ← Science in Society (SSO 0A) ←		OAC

Note: Prerequisites to the OACs are shown by arrows

By focussing on science-related issues, science education can contribute to the building of effective citizens by helping students to acquire decision-making skills, to develop values and, if appropriate to reserve judgement for a future time. The study of issues in the science classroom will also provide students with the opportunity to think clearly and logically and to deliberate honestly and openly. Other values reflected in actions such as taking a stand against unnecessary pollution, maintaining premises in good conditions, seeking both the weaknesses and strengths in a theory, demanding substantive evidence, and considering societal consequences of scientific discoveries are also encountered in discussing issues and in forming sound opinions.

Further, because issues frequently contain important moral components, students have the opportunity to consider the ethical implications of various points of view in the light of fundamental societal values.

Science Education which focuses on issues is personal and/or relevant science. When students experience science from this perspective, they feel more than a passing interest in the investigative process and in its potential solutions. However, one must take special care when using issues as organizers for the science curriculum. To adequately study a science-related issue, one must include three elements in that study: Scientific knowledge, its application as technology, and the resulting societal implications.

To achieve this major purpose, each unit of study in each course includes mandatory sections on practical applications and societal implications. Each unit in every course contains the following subheadings:

1. Objectives: attitudes, skills, knowledge (intended curriculum)

2. Student activities

3.* Applications

4.* Societal Implications

5. Evaluation of student achievement

6. Safety considerations

7. Possible extensions (Enrichment)

8. Some teaching suggestions

* These sections, in each case, are intended to illustrate the use and relevance of science and the interaction between science and society and to add interest and excitement to the subject matter.

In addition to the sections on applications and societal implications in each unit of each of the twenty-seven courses developed, there are complete units with a science, technology, society focus included in the grades 9 and 10 Science courses and the grade 11 Chemistry course titled Science and Society, Waste Management and Industry and Society respectively. An Ontario Academic Course titled Science in Society has also been developed for non-science oriented students.

To illustrate the direction and the emphasis of the intended treatment of the Science, Technology, Society Components in the Ontario Curriculum, the following outlines of portions of units, units and courses are presented.

1. The grade 9 Advanced Level Science Course is composed of six core units.

a) Structure of matter
b) Chemical Change
c) Geometric Optics
d) Cells and Cell Functions
e) Green Plants
f) Food and Energy

and three optional topics

a) Science in Society
b) Science Project
c) Locally Designed Unit

one of which is to be developed for presentation. Within the core unit, Cells and Cell Functions the, following applications and societal implications are offered for consideration and are mandatory.

Applications:

a) Microscopy is used in almost all scientific disciplines including geology, metallurgy, forestry, physiology, medicine, chemistry and physics;

b) Scientists use their knowledge of cells to study food production, genetics and the effects of pollutants on organisms;

c) Our knowledge of cell structure and function has contributed to the battle against diseases as indicated by immunization and the use of antibiotics.

Societal Implications:

a) As a result of research on cells, human health and nutrition has been improved and new treatments for diseases have been discovered. Consequently the average life span of humans has been increased.

b) Cell cloning as a method of reproduction and genetic engineering as a technique for deliberately altering the chromatin of organisms may have economic, legal, and moral consequences.

c) An understanding of cell maturation and ageing may help humans more effectively control the ageing process.

Within the optional units suggested a unit on Science and Society is outlined. The unit provides opportunities for students to make informed decisions about social issues that are part of their lives. The issues selected for study have a significant science component and are topical, interesting and important. One goal of the unit is to prepare young people to make rational and ethical decisions. The emphasis in the unit is on the process used to reach a rational decision rather than the decision itself. As a result, it is hoped that the student will gain an insight into some of society's specific problems and examine the role of his/her own values and beliefs in the possible solution to such problems. In the development of this unit, it is essential that the students come to realize that in dealing with social issues methods of science alone will not lead to a solution to the problem. Science must share information and techniques with law, economics, religion, politics and technology in order to arrive at a workable solution. This unit on Science and Society contains teaching suggestions for one sample societal issue from each core unit. There are many societal issues mentioned in each unit of this course. It is suggested that the most appropriate way to implement Science and Society would be to study one or more of the societal issues raised during each unit rather than in a single block of time at the end of the course. It is recommended that the Science and Society unit be integrated with the core units as the year progresses. The issue described for core unit 2: Chemical Change under the topic: Physical and Chemical Changes is the conflict between the harmful and beneficial effects of a chemical or physical change. The teaching strategy suggested in this instance is the evaluation of alternatives - problem solving. The unit (topic) is divided into the following areas for discussion:

Recognition of an issue and the domains of knowledge involved, scientific facts, assumptions and limits of science,

Decision making processes,

Recognition of values and beliefs.

Much flexibility is provided in this unit. It is stressed that it is not necessary to use the issues described. Many other problems exist which can be related directly to the content of this course.

2. Grade 11 Advanced Level Chemistry is composed of seven core units

a) Matter
b) Elements and Bonding
c) Gases
d) Chemical Reactions
e) Chemical Reaction Calculations
f) Solutions
g) Industry and Society

The unit on Industry and Society is a totally new concept in Ontario Curriculum and is intended to provide a Science and Society focus in the course. The purpose of this unit is to provide students with opportunities to consider their responsibilities as citizens in a technological society, to acquire some of the scientific and technological knowledge that they will need in order to make informed decisions, and to understand the role played by a particular chemical industry as it supplies products to satisfy the demands of society.

No specific chemical industry is mandated for study. Any number of different chemical industries could be chosen for study and could logically be based on industrial development in a given region.

The unit may be divided into the following topics:

a) Chemicals produced by an industrial society,
b) Factors affecting a selected chemical industry,
c) Location and environmental concerns,
d) Human resources.

Suggested applications

a) Chemicals and products resulting from chemical processes are used by students in their homes, the school, and the community. Some might be related to the industry under study.

b) Chemicals are used in large quantities in industrialized societies.

Some Societal Implications

a) Much of the success of any Nation's Chemical Industry depends on its being innovative in Science and Technology. Intensive research and development by chemical industry can help Canada remain competitive in the international marketplace.

b) Citizens receive the benefits from Chemical Industries and, accordingly, must share the responsibility for helping to diminish the accompanying social and environmental problems.

c) The benefits of industrial development are often accompanied by social disruption and environmental problems, particularly in Third World Countries.

3. The Ontario Academic Course (OAC) - Science in Society is composed of six core units and two optional units, one of which is to be selected for study.

Core Units:

a) Design in Nature
b) Science at Work
c) Life, Food, and Health
d) Resources and Energy
e) Scientists and their Discoveries
f) Transportation and Communication

Optional Units

a) The Human Consumer
b) Conflicts Related to Science

This course is designed to help non-science-bound students explore the realm of science in the world around them both in the present and in the future. It is intended to provide students with insights into the following issues:

a) What scientists do
b) Characteristics of good science
c) Areas of science in which Canada excels
d) The role of citizens in influencing the wise use of scientific discoveries
e) Conflicts which may arise in society when scientists, politicians and economists give different interpretations to scientific data.

It is hoped that the major outcome will be that students will view science as a human endeavour. The course offers a holistic and integrated experience to the students rather than a specialized approach. The major disciplines (Chemistry, Physics and Biology) provide input which the science teacher is expected to present to the non-science oriented student in an integrated way.

In the unit "Conflicts Related to Science", the following controversial scientific topics are suggested for discussion.

a) Conflicts associated with reference frames, eg., Copernican Revolution, Galileo and the Church,
b) Nuclear Power,
c) Population Control,
d) Food Additives,
e) Theories of the Origin of Life,
f) Genetic Engineering,
g) Animals used for Research,
h) The Balance of Nature.

The Ontario Ministry of Education has prescribed the inclusion of practical applications and societal implications in our science curriculum. A viable rationale for doing so has been provided and the subject content has been designated. The successful integration of this content into the science curriculum will be difficult and the intended implementation of these components of the curriculum will be limited, if successful at all, for a variety of reasons. The teachers, for the most part, do not have the necessary background and experience to do so. No in-service programs are planned to provide this background and experience. Consequently, it is likely that only a few interested, highly motivated teachers will become involved. No suggestions are offered as to how these sections and /or units might be effectively integrated into the various units and/or courses described. The sections are provided simply as add-ons to the units and/or courses with no intention that the content be developed in detail. It is left totally up to the teachers to decide what should be done and how it should be done. No resources are provided and no plans have been made for developing required resources for use in achieving the proposed objectives. Insufficient time, after the prescribed content of the discipline is presented, is available to adequately treat the content related to Science, Technology and Society that is prescribed. Unless some radical changes are made, as part of the implementation process, to alleviate these problems, the Science, Technology, Society Challenge offered in the Ontario Science Curriculum will not be met.

Reference

Science Curriculum Guideline, Intermediate and Senior Division, Pre-Edit Drafts, Parts 1 to 15, Ontario Ministry of Education and Ministry of Colleges and Universities, December, 1986.

Statement regarding:

a) The Pre-University Educational System in my Country-

The pre-university education of our young people extends over a period of 14 years. There are three over-lapping stages in the system;

i) Primary-Junior which extends from Kindergarten to grade six;
ii) Junior-Intermediate which extends from grade four to grade ten;
iii) Intermediate-Senior which extends from grade seven to grade thirteen (the OAC courses).

On the average, students start school with Kindergarten at age 5. At age 10, the students move from the Primary division (Kindergarten to grade 3) to the Junior division (grade 4 to grade 6). At age 12, the students move from the Junior division to the Intermediate division (grade 7 to grade 10). At age 16, the students move from the Intermediate division to the Senior division (grade 11 to grade 13 - OAC Courses). On the average, students enter university at age 19. With the new guidelines and policies related to the new curricula being implemented, the students may enter university at age 18. The mode of assessment used for university entrance is totally school based. Assessment is multifaceted. A wide variety of assessment techniques are used to evaluate all aspects of the student's performance. A minimum of 30% and a maximum of 50% of the assessment is examination based. The remaining 50% to 70% of the assessment is based upon the student's term work. University entrance is based on the grades submitted to the university by the schools.

b) The paper prepared fits into the Intermediate-Senior Division of our educational system in Ontario (Canada).

c) Brief autobiographical note:

Educational Qualifications

B.Sc. and M.Sc. in Chemistry, 1950, 1951, The University of Western Ontario, London, Ontario

Specialist Teaching Certificate in Science, 1952, College of Education, The University of Toronto, Toronto, Ontario.

Interim Principal's Certificate, 1963, The Ministry of Education,Province of Ontario, Toronto, Ontario.

Employment History:

Teacher of Science, 1952 - 1958.
Head of the Science Department, 1958-1964.
H.B. Beal Secondary School, London, Ontario.
Vice Principal, Clarke Road Secondary School, London, Ontario, 1964-1965.
Associate Professor, Science Education, 1965-1971.
Professor, Science Education, 1971 to present.
Coordinator of the Science Department, 1974 to present.
Faculty of Education, The University of Western Ontario, London, Ontario.

Publications:

Secondary School Chemistry Textbooks

Chemistry- A Search For Understanding Book I.

Chemistry - A Search For Understanding: Laboratory Manual, Holt Rinehart and Winston Company of Canada, Toronto, Ontario, 1971.

Numerous papers on Curriculum and Instruction in Chemical Education at the Secondary School level.

Reaction papers on the state of Chemical Education in Ontario.

Major contributions in Curriculum Development in High School Chemistry, 1969 - 1987, with emphasis, in the last several years on Science, Technology and Society.

THE DEVELOPMENT OF A NEW TECHNIQUE FOR MONITORING STUDENT UNDERSTANDING OF SCIENCE-TECHNOLOGY-SOCIETY

Glen S. Aikenhead (Canada)

Introduction

Evaluating what students learn is a challenge to both classroom teachers and educational reserachers. For many teachers, such evaluation in the science-technology-society (STS) domain has been a major obstacle to implementing STS materials in science classrooms. For researchers, standardized instruments have not yielded data precise enough to accurately monitor student understanding of STS. A new type of instrument, an empirically developed, multiple-choice inventory pool, promises accurate data for both classroom teachers and STS reserachers. The purpose of this paper is to report on the methodology of this new development.

Scope and Background to the Study

The study focuses on one strategy for monitoring student beliefs about STS topics; namely, objectively scored items. Other methods such as essay writing, oral examinations, reports, projects, and check lists, are beyond the scope of the paper.

The STS topics included for consideration are limited to those emphasizing student cognition rather than attitude (the distinction can often be extremely fuzzy, and attitude research is particularly problematic; Gradner, 1975; Gauld & Hukins, 1980; Munby, 1980, 1983). Thus, attention is not given to students' feelings about global or regional issues. Instead, the study focuses on the *reasons* that the students give to justify an opinion -- their *informed* viewpoints, their cognitive beliefs.

Over the past 25 years several standardized instruments have been developed to quantify, and therefore assess, student understanding of STS topics -- the epistemological, technological and social contexts of science. Instruments include: *Test on Understanding Science*, (Cooley & Klopfer, 1961), *Nature of Science Scale*, (Kimball, 1965), *Science Process Inventory* (Welch, 1966), *Test of the Social Aspects of Science* (Korth, 1968), and *Nature of Scientific Knowledge Scale* (Rubba, 1976); and subscales within: *Scientific Attitude Inventory* (Moore & Sutman, 1970), *The National Assessment of Education Progress* (Bybee, Harms, Ward & Yager, 1980; Hueftle, Rakow & Welch, 1983), and *Attitude Toward Science Scale* (Hasan, 1985). These instruments have provided empirical data for researchers, and have guided policy makers and curriculum developers (Aikenhead, Fleming & Ryan, 1987).

The instruments, however, have a problem. One must assume that both the student and the assessor perceive the same meaning in the instrument's items, and that a response "agree" or "disagree" means the same thing to both student and assessor. This assumption, called "the doctrine of immaculate perception" by Munby (1982), originally motivated this study.

The Study

In order to improve upon the accuracy of the instruments listed above and to diminish the problem of "immaculate perception," students' written responses were investigated. Using a stratified sampling of classrooms from across Canada in the International Association for the Evaluation of Educational Assessment (IEA) science study, Aikenhead, Fleming and Ryan (1987) analyzed Likert-type and written paragraph responses from 10.800 graduating high school students. The students were asked to react to a statement concerning a STS topic by (a) stating whether they agreed with the statement, disagreed, or couldn't tell; and (b) writing a paragraph explaining the reasons for the choice. Each student had responded to one statement from Views on Science-Technology-Society (VOSTS) form CDN.2 ("CDN" for "Canada"), an instrument comprised of 46 statements based on 16 major STS topics (Aikenhead, 1985b).

VOSTS Content

VOSTS was, in part, based on the theoretical models which had validated the standardized instruments listed above. Its content also grew out of the more recent literature on the social and technological contexts of science (e.g. Aikenhead, 1985a; Gauld, 1982; Ziman, 1980), views often ignored in the earlier science education literature (e.g. the role of women in science, scientists and values, the effect of social interactions on knowledge discovered, and socioscientific decision making).

Analysis of Responses

The paragraph responses obtained in the IEA study were analyzed to detect students' common arguments or justifications (Aikenhead, Fleming & Ryan, 1987). These common student positions were paraphrased using the students' vernacular as much as possible. The student positions (ranging between 5 and 13 per statement) constituted a rough draft of an empirically developed multiple choice, form CDN.mc.1 (Aikenhead & Ryan, 1986).

How well did the paragraphs communicate students' beliefs? The next phase of the study investigated the degree of ambiguity harboured by four different response modes. With a sample of 108 grade 12 students, Aikenhead (1987) found the following:

response mode	approx. degree of ambiguity
Likert-type	90 %
Argumentative paragraph	50 %
Choice of "student positions"	20 %
Semi-structured interview	5 %

The semi-structured interviews allowed the researcher to probe student meaning and to deal with specific issues in depth. It was discovered that the empirically developed multiple-choice responses (the student positions) were claimed by students to be as accurate or more accurate than their paragraph responses over 80% of the time.

Further Revisions

VOSTS was then revised into a multiple-choice format, form CDN.mc.2. The 10.800 paragraph responses and the 108 semi-structured interviews guided the selection, modification, and addition of a few VOSTS statements. The 10.800 Likert-type responses suggested a sequence for the student positions for each statement. These positions were recast stylistically (e.g. to give parallel sentence structure) without altering the original student paraphrases.

In the next phase of the study, students worked through VOSTS form CDN.mc.2, verbalizing their thoughts as they read and made their choices. They also commented on the clarity of student positions, the physical layout of the items, the ease of responding, and the suitability of the instructions. This feedback was incorporated into the next revision, form CDN.mc.3.

This new version of VOSTS had 42 statements, each with a varying number of choices (6 to 14), and each ending with the same three choices: (a) "I don't understand," (b) "I don't know enough about this subject to make a choice," and (c) "None of these choices fit my basic viewpoint, which is ..." (students had the opportunity to provide their own position). Due to the length of the instrument (about 75 minutes to complete), and due to some statements being variations on a theme, VOSTS form CDN.mc.3 should be thought of as a pool of items. Hence, various versions of VOSTS can be compiled by selecting items from the pool.

The efficacy of the VOSTS inventory pool was tested with approximately 1.500 high school students from across Saskatchewan. The conditions were typical of a large scale evaluation project. Each student responded to one of three parallel versions of VOSTS form CDN.mc.3. Based on this feedback, a small number of student positions were altered (according to the spontaneous paragraph responses received), and some student positions were deleted (those receiving less than a five percent response). Improvements to the answer sheet were also made as a result of student and teacher reactions.

Although the issue is beyond the scope of this paper, it is instructive to note that the student responses to VOSTS form CDN.mc.3 express, more accurately than the paragraph responses did, the beliefs about STS topics that Saskatchewan students hold. These results may be cautiously generalized to the national level, because the variation in student positions among the regions of Canada is negligible (Aikenhead & Ryan, 1976).

Conclusion

The end product of this study, VOSTS form CDN.mc.4, is a reasonably accurate, efficient tool for monitoring student viewpoints on the following STS topics:

Science and technology	5 items
Technocratic/democratic decision making	8 items
Scientists and socioscientific decisions	1 item
Science/technology and social problems	1 item
Influence of society on science/technology	5 items
Social responsibility of scientists	3 items
Motivation of scientists	1 item
Scientists and their personal traits	7 items
Women in science and technology	2 items
Social nature of scientific knowledge	1 item
Characteristics of scientific knowledge (scientific method, models, classification schemes, tentativeness)	8 items

Because VOSTS is an item pool, any particular combination of items may be selected by the user and edited to replace Canadian references with, for instance, German (Deutschland) references -- form D.mc.1. One always has the option of replacing the multiple-choice responses with paragraph responses. One can also add new statements to the VOSTS pool and then analyze the paragraph responses as outlined above, thereby generating a set of student positions for a new STS topic.

VOSTS form CDN.mc.4 does not encompass all STS topics. It could be expanded to include, for example: (a) politics and science, specifically the new alliance between university labs and industry (Dickson, 1984); (b) specifically topics of design, resources, R. & D management, appropriateness, and transfer (Harrison, 1980; Pacey, 1983; Ziman, 1984).

The VOSTS inventory pool can serve as a point of departure for (a) creating an international item pool, (b) developing items for other STS topics, (c) making cross cultural comparisons, and (d) generating a custom evaluation instrument to suit a particular STS curriculum or teaching situation. VOSTS offers accurate data and administration ease for both classroom teachers and STS researchers.

Acknowledgement

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Pre-University Education in Canada

Canada has 10 provinces and 2 territories. This results in 12 different independent educational systems. The following is a rough summary:

Kindergarten to grade 8 (ages 5 to 13) -- "elementary"
Grades 9 to 12 (ages 14 to 17) -- "high school"
(High schools vary from strictly academic to including both academic and vocational streams of students.)

Variations in some provinces: K. to gr. 6 (elementary)
gr. 7 to 9 (junior high)
gr. 10 to 12 (high school)
Ontario, with about half of Canada's school population, offers grade 13, an academic year in the high school.

The research and development described in this paper applies to students in grades 12 and 13.

Autobiographical Note

Born and raised in Alberta, Canada, I have taught high school science and mathematics in Alberta (1966-67), at the Frankfurt International School (West Germany, 1967-69) and at the Leysin Americian School (Switzerland, 1975-77). My formal education qualifications are: Honours B.Sc. (chemistry, University of Calgary, 1965), Master of Arts in Teaching (science education, Harvard University, 1966), and Doctorate of Education (science education, Harvard University, 1971). Since 1971, I have taught in the College of Education, University of Saskatchewan, Saskatoon, Canada, except for the two years of teaching in Switzerland. My publications have principally dealt with the evaluation of student learning (e.g. my doctoral dissertation, 1971, and the present paper), science education curriculum policy (e.g. *Science in Social Issues*, 1980), curriculum development projects related to STS (e.g. *Science: A Way of Knowing*, 1975, *Scientific Decision Making*, 1984, and *Logical Reasoning In Science & Technology: Alcohol, Driving & You*, in press), and ethnographic studies (e.g. "Prairie High", 1982).

A COMPARISON OF STUDENT/TEACHER POSITIONS ON SELECTED SCIENCE/TECHNOLOGY/SOCIETY TOPICS: A PRELIMINARY STUDY

by

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U.S.A.

The purpose of this paper is to share some preliminary data from a study which is currently in progress in the United States. The study is using a modified version of nineteen statements from the Interaction of Science/Technology/Society Section of the Views on Science, Technology, Society - Form CDN-2 assessment instrument designed by Aikenhead, Fleming, and Ryan (1987).

The VOSTS assessment requires the respondent to make an initial choice of agree, disagree, or can't tell followed by a written argumentative response to the S/T/S statement. Rather than analyzing the agree/disagree answers as is so frequently done in assessment instruments of this type (TOUS, NOSS, SPI, TSAS), the VOSTS uses the respondents arguments to define various positions or viewpoints on each S/T/S topic. This approach to the assessment of S/T/S understanding emphasizes cognition through concentrating on informed opinions. It also attempts to overcome what Munby (1982) has described as "the doctrine of immaculate perception." The "doctrine" is often harbored in objectively scored tests where a respondent's choice carries the implicit assumption that both the respondent and the researcher perceive the same meaning in the test item. What is often overlooked is that the respondent makes his/her own meaning out of the item. The result is what appears objective to the scorer becomes quite subjective to the respondent. It has been suggested by Aikenhead, Fleming, and Ryan (1987), that a multiple-choice format for VOSTS is possible by using the respondent's positions as choices and by using each pair of statements as a type of stem. The fact that the wording itself originated from a large respondent sample might reduce the "immaculate perception" problem.

This study used a stratified sample of 564 students from schools in Iowa, California, Massachusetts, Utah, and Wyoming. The students ranged from 13-18 years of age with a mean age of 15 years old. Students were enrolled in one of the following types of science classes; earth science, physical science, life science, biology, chemistry, or physics. The teacher sample consisted of 61 teachers from schools in California, Iowa, Massachusetts, Utah, and Wyoming. Teachers ranged from 25-60 years of age with a mean age of 43 years old. All of the teachers involved in the study taught either science or S/T/S topics. The student sample had 52% females to 48% males, and the teacher sample had 56% females to 44% males.

The only modifications made in the VOSTS - Form CDN-2 as used in the United States study involved changing the words Canadian and Canada to American and United States, respectively. Otherwise the content of the statements was unchanged and the format consisted of using a statement paired with its converse.

The United States study was modeled after the study carried out by Aikenhead, Fleming and Ryan (1987), with a large sample of Canadian students. In the U.S.A. study, both student and teacher populations received a random sample of five of the possible nineteen statements. The respondents were asked to make a choice of agree/disagree/can't tell followed by an argumentative position explaining why they selected the choice they did. This format generated at least 138 student opinions for each statement, and 12-18 teacher opinions for each statement. These opinions were then assembled into a collection of "Student Positions" and "Teacher Positions." All student opinions for a given S/T/S statement were used to ensure "theoretical saturation" (Glaser and Strauss, 1967). Saturation is a sociological research technique which implies that as the researcher observes similar responses over and over again, he/she becomes empirically confident that a particular category is saturated. For this study, saturation would imply that after reading anywhere from 85-135 usable student opinions the researcher could feel confident that no different opinions would be found regarding that particular S/T/S statement. This points up a severe limitation in the collections of "Teacher Positions" at the time of this writing. The number of teacher opinions is well below the accepted level for "theoretical saturation." However, the "Teacher Positions" have been included to at least examine any trends which might exist. It is expected that a larger teacher data pool will be available for analysis by the time of the Symposium Meeting in August. The reader should be aware that the "Teacher Position" percentages are somewhat inflated due to the low numbers of opinions in each collection.

Another limitation of the study at this time is the lack of establishing a closeness of fit between respondent's opinions and student/teacher positions. I am currently working on the study alone and have only been able to perform cross-checks on myself. In an attempt to at least address the issue, a subsample of fifty percent of the student and teacher responses were randomly selected for seven of the nineteen statements. This was done one week after the initial analysis. The reliability of categorizing ranged from 76% to 96% with a mean of 86% agreement.

As in the case of the study completed by Aikenhead, Fleming, and Ryan (1987), a respondent's overall reaction, e.g. agree, disagree, can't tell, was open to frequent misunderstanding. Oftentimes, respondents would agree and disagree with a particular statement but offer the same justification. Therefore, the central focus of the analysis became the respondent's argumentative statement. When a respondent expressed more than one position, the one indicated as most important was used. After deciding which opinions were clustered in the same categories, the opinions became student or teacher positions.

Two other types of categories were used, "unique responses" and not usable. Unusable responses included those for which, 1) no opinions were written; 2) the original statement was simply repeated; and, 3) the opinion had nothing to do with the statement. "Unique responses" were those opinions which pertained to the statement but lay outside the content of all other opinions presented.

Both the "Student Positions" and "Teacher Positions" are shown as a percentage of students or teachers holding that position. This percentage is based on the number of usable responses. All percentages are rounded off to the nearest whole number. The proportion of unusable responses is reported on the bottom of each tabulation as a percentage of the total number of sheets analyzed.

Entire analysis of the study is beyond the scope of this paper due to restrictions on length. Therefore, discussion of ten of the nineteen statements will be made in this paper with the remaining data being shared in the formal presentation at the Symposium in August, 1987.

TABLE 1

1.1 Scientists and engineers should be given the authority to decide what types of energy the United States will use in the future (e.g. nuclear, hydro, solar, coal burning, etc.), because scientists engineers are the people who know the facts best.

1.2 Scientists and engineers should be the last people to be given the authority to decide what types of energy the United States will use in the future (e.g. nuclear, hydro, solar, coal burning etc.). Because the decision affects everyone in the United States, the public should be the ones to decide.

Student Positions	% of Usable Responses 1.1	% of Usable Responses 1.2
A. Scientists and engineers have more training and knowledge in this field of energy and therefore, should be able to decide what is best.	49	37
B. Scientists and engineers know the most about energy, but the public should have some voice in the decision.	28	21
C. The people should have the right to decide what type of energy they want.	16	13
D. The public really doesn't know much about energy and may make the wrong decision.	-	19
E. The scientists and engineers should inform the public so that the public can make the final decision.	-	7
F. The government should have some authority on deciding which energy source to use since they are protecting our common interests.	3	-
G. The scientists and engineers know the most about energy, however, they may choose the most expensive.	3	-
H. If the choice is given to the scientists and engineers, they may not know what is best for the public.	-	3

10% and 8% of total responses for 1.1 and 1.2, respectively, were not usable

Teacher Positions	% of Usable Responses 1.1	% of Usable Responses 1.2
A. Scientists have the expertise and the ability to know the implications of all aspects of the problem.	28	60
B. Scientists and engineers should provide information to the public who in turn should have considerable input into the decision.	61	27
C. Scientists and engineers should be included as one of several voices in the decision making process.	6	7
Unique responses	7	6

All responses for 1.1 and 1.2, respectively, were usable.

TABLE 2

3.1 American scientists should be concerned with the potential effects (both helpful and harmful) that might result from their discoveries.

3.2 American scientists should not be concerned with the potential effects (both helpful and harmful) that might result from their discoveries.

Student Positions	% of Usable Responses	
	3.1	3.2
A. Scientists should always be concerned with the outcomes of their discoveries otherwise something terrible could happen.	54	40
B. Scientists can't predict what will be helpful or harmful.	11	14
C. Scientists should be morally responsible for their actions.	10	31
D. Scientists should examine the pros and cons of their research before they begin.	13	7
E. Society should know all the facts unless the facts make the world a worse place to live, then the facts shouldn't be mentioned.	2	3
F. Scientists want the best for people that is why they are doing research.	2	3
G. Scientists should be concerned that their discoveries might fall into the wrong hands and be used for evil purposes.	4	3
Unique responses	4	-

21% and 20% of total responses for 3.1 and 3.2, respectively, were not usable.

Teacher Positions	% of Usable Responses	
	3.1	3.2
A. The only way a democratic system can function is if the average citizen is informed and becomes more knowledgeable about scientific discoveries	15	12
B. Scientists must be aware of all the possibilities and and eventualities of their discoveries and proceed with care and moral insight.	69	76
C. Scientists need the freedom to investigate and not be concerned with the use of their discoveries.	15	-
D. Harmful effects need to be considered, but should not necessarily result in abandoning the research.	-	12

13% and 6% of total responses for 3.1 and 3.2, respectively, were not usable.

TABLE 3

4.1 American scientists should be held responsible for harm that might result from their discoveries.

4.2 American scientists should not have to be responsible for harm that might result from their discoveries.

Student Positions	% of Usable Responses	
	4.1	4.2
A. Before scientists introduce a discovery, they should consider the results and make certain the discovery is safe.	33	22
B. The public is responsible since they use the discovery.	17	6
C. Scientists have no way of predicting what will happen and therefore, should not be held responsible.	24	21
D. Scientists should be held responsible for what they produce.	17	38
E. If scientists were held accountable, it might hinder research since they would be afraid to experiment.	6	3
F. Society asks the scientist to find things out; therefore, society should accept part of the responsibility.	2	10

9% and 12% of total responses for 4.1 and 4.2, respectively, were not usable.

Teacher Positions	% of Usable Responses	
	4.1	4.2
A. The misuse of the scientist's discovery is not the fault of the scientist.	53	8
B. The scientist should be able to suggest whether or not a discovery should be put to use.	13	33
C. Scientific research would diminish considerably if scientists were held responsible for harm that might result from their discoveries.	20	-
D. It should be the responsibility of the public how discoveries are utilized.	7	-
E. Scientists should have some moral responsibility to society.	-	58
F. There should be enough controls on the system to prevent any harm to the public.	7	-

6% of the total responses for 4.1 were not usable.

TABLE 4

5.1 American scientists should be held responsible for reporting their findings to the general public in a manner that the average citizen can understand.

5.2 American scientists should not have to feel responsible for reporting their findings to the general public in a manner that the average citizen can understand.

Student Positions	% of Usable Responses	
	5.1	5.2
A. The public has a "right to know."	51	36
B. Some explanations in science are just difficult for the public to understand.	6	4
C. Someone else should translate the work of the scientist so it is understandable to the average citizen.	10	13
D. Scientists should make their work understandable to the public so that their discoveries can be of use.	13	19
E. If people want to find out about a scientist's work, then they should make it their business to find out for themselves.	2	10
F. It is not necessary to report a scientist's findings to the average citizen unless the public interest is involved.	1	11
G. If the finding is harmful the scientist should tell government leaders, but not tell the public because it might cause a panic.	10	5
H. If the government is paying for the research, the scientist has an obligation to report his/her findings to the public.	-	2
I. Scientists shouldn't be forced to do or tell anything to anyone.	7	-

11% and 17% of total responses for 5.1 and 5.2, respectively, were not usable.

Teacher Positions	% of Usable Responses	
	5.1	5.2
A. New knowledge should serve all people everywhere and the scientist should take some responsibility for the process.	36	50
B. There are others who can explain or simplify science much more easily.	14	17
C. Scientists should feel responsible if such discoveries are used directly by the public.	7	17
D. Not all citizens are interested or have a need to know.	7	8
E. Not all scientific findings can be easily reported.	14	8
F. Proper preparation and education of the citizenry is the responsibility of government agencies.	14	-
Unique responses	7	-

12% of the total responses for 5.1 were not usable.

TABLE 5

6.1 Although advances in science and technology may improve living conditions in the United States and around the world, science and technology offer little help in resolving such social problems as poverty, crime, unemployment, overpopulation and the threat of nuclear war.

6.2 Science and technology offer a great deal of help in resolving such problems as poverty, crime, unemployment, overpopulation and the threat of nuclear war.

Student Positions	% of Usable Responses	
	6.1	6.2
A. Discoveries lead to technology which has helped to solve many of these problems.	59	54
B. These are social problems that need to be solved by people, not science and technology.	22	17
C. Science and technology deal with problems outside these areas.	6	-
D. Science and technology have created many of these problems, but are also capable of solving them.	6	16
E. The government is responsible for solving these problems.	2	12
F. Science and technology have made things worse.	2	-
G. Neither science and technology, nor anyone else, can solve these problems.	2	-

39% and 42% of total responses for 6.1 and 6.2, respectively, were not usable.

Note: Of the unusable responses, 46% and 39% of the responses for 6.1 and 6.2, respectively, chose "Can't tell" and said they did not know enough about the topic or were ambivalent about the decision.

Teacher Positions	% of Usable Responses	
	6.1	6.2
A. Advances in societal and political institutions are needed to solve these problems.	36	22
B. Advances such as problem solving techniques in science and technology have been used to solve social problems.	64	22
C. Science and technology can offer ideas, but they are only valuable if they are used.	-	44
D. These problems are not the concern of science and technology.	-	11

31% and 25% of total responses for 6.1 and 6.2, respectively, were not usable.

Student and teacher positions for statements 1.1 and 1.2 in the VOSTS-Form-USA are summarized in Table 1. Statement 1.1 represents a technocratic viewpoint and is supported by 48% of the students and 28% of the teachers (Positions A & A). Student position B (28%) and teacher position B (61%) have a similar respect for the knowledge of scientists and engineers but have moved to a more democratic view of decision making. Student position C (16%) and teacher position C (6%) demonstrate an even greater participatory view of decision making by the public. Student positions F and G suggest that scientists and engineers are not knowledgeable enough about the public interest. Statement 1.2 expresses a very democratic position regarding energy. Though the majority of student positions remain stable, student position D (19%) questions the capability of the public to make an informed decision about energy. This would suggest support of a technocratic view of decision making. Teacher position A (60%) demonstrates a dramatic increase in a technocratic view of decision making. This dramatic increase is combined with a dramatic decrease among those supporting a more democratic view in position B (27%). It would be interesting to pursue the impact of the phrase, "last people to be given authority" in statement 1.2.

Student and teacher positions for statements 3.1 and 3.2 are summarized in Table 2. At least 77% of the students (Positions A,C, and D) perceive science as under the influence of social control. Support for this position among the teachers is even greater (84%). There is some recognition by student position B, (11%), that science is not predictable in terms of use by society. Teacher position C (15%) actually distinguishes between the discovery and its use. It is of interest that student position E would rather not receive any bad news. Student position G begs the question of the impact of the media on portraying science in evil hands. When the statement is shifted to no social control over science (3.2), Student position C demonstrated a gain of 21% expressing the view that scientists should be morally responsible. No major shifts occurred in the teacher positions except that position D qualified a concern for harmful effects but still felt that the research should be pursued (12%). In all cases both students and teachers seemed to zero in on the potential harmful effects rather than viewing the potential effects in a more neutral way. It would be interesting to ask for responses to the same statements eliminating the words helpful and harmful.

Statements 4.1 and 4.2 specifically address the concern of harm. Student positions A and D for 4.1 (50%) indicate a desire to have some social influence on science. However, student positions B,C,E and F express varying degrees of a more democratic view of responsibility. All of the teacher positions suggest some degree of democratic responsibility. However, in the more democratic statement, 4.2, student position D shows an increase of 21% in scientists being held responsible for their discoveries. A major shift is seen in the teacher position E where in 4.1 moral responsibility was not mentioned, whereas in 4.2 58% of the teachers supported this position. This major shift was reinforced by the dramatic decrease in teacher position A (45%).

Statements 5.1 and 5.2 in Table 4, once again address the issue of social influence over science or a more democratic view of no influence. The positions for both students and teachers are spread along a continuum which supports the "right of the public to know" and supports the "rights of the scientist" to not be forced to do or tell anything to anyone. Half the students (Position A) favored the public's right to know on 5.1 but when confronted with the converse statement in 5.2 dropped to 36%. The corresponding teacher position A had 36% of the teachers supporting this view on 5.1 but raised to 50% when given the converse statement of 5.2. Both students (Position C) and teachers (Position B) supported the idea that people other than scientists could explain or simplify science so that the general public could understand it. It would be worth pursuing the role of popularized science magazines to see if there is any correlation with their use by the individuals who supported this view. Student position B and teacher position E once again supported the view that some areas of science are not able to be grasped by the public. Student position G suggests an approach which we saw earlier when analyzing statements 3.1 and 3.2, i.e., if the findings are harmful don't tell the public.

Student and teacher positions for statements 6.1 and 6.2 are summarized in Table 5. These statements deal with quality of life issues and specifically social problems. In responding to the statements, students tended to concentrate on one or more of the specific problems whereas the teachers concentrated on the social problems as a single entity. It would be of interest to present the statements with the specific problems eliminated to see if respondents would express their opinions any differently. The majority of students (59%) supported the view (Position A), that science and technology have influenced social problems in a positive way. Teacher position B (64% on 6.1) emphasized the role of problem solving as the major contribution of science and technology. Student positions B and C felt that science and technology could not solve social problems. Teacher position D stated that same belief, however, the belief was triggered by statement 6.2 and not 6.1. When given the optimistic view expressed in 6.2, student position D increased 10%, eliciting the opinion that science and technology had created [illegible] many of these social problems. Statement 6.2 elicited a much more optimistic response from teacher position C (44%) and suggested that people decide the appropriate use of science and technology. Perhaps the most significant information obtained from responses to 6.1 and 6.2 were the large number of students who were unable to make a response because they did not know enough about the topic or felt ambivalent about the decision.

In examining the closeness of fit between student positions and teacher positions for the ten statements analyzed, statement pair 3.1/3.2 showed the least (25%) and statement pair 5.1/5.2 showed the greatest agreement (83%). In general the teacher positions were fewer in number , in part due to a small sample size.

This study demonstrates the efficacy of the VOSTS instrument as a means of obtaining useful information for assessing S/T/S understanding in a variety of populations. It also demonstrates the VOSTS usefulness in cross-cultural studies and as a potential source for designing a new generation of multiple-choice S/T/S instruments.

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The educational program in most American schools takes on the following characteristics:

1) Elementary School - Kindergarten - Grade 6; Ages 6-12

2) Middle School Grades 5-9 Ages 11-15
6-8 Ages 12-14
7-8 Ages 13-14

or

Junior High School Grades 7-9 Ages 13-15
Grades 7-8 Ages 13-14

3) High School Grades 9-12 Ages 15-18
Grades 10-12 Ages 16-18

The mode of assessment for entrance into the university is Grade Point Average, Scholastic Aptitude Test (SAT) or American College Testing Examination (ACT).

This paper fits into the area of STS assessment. With the current interest in an STS approach to science instruction in the United States, concerns are being raised regarding the assessment of STS understanding.

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RESEARCH ON STUDENTS' REACTIONS TO STS ISSUES

(Joan Solomon (Oxford University, England)

Now that STS materials have won enough recognition to be included in many school science curricula it is time to assess the various purposes for which they have been introduced, the claims made for each of these, and what research evidence there is to justify such claims.

Categories of STS

School STS materials are essentially interdisciplinary. It is not posible to categorise them by academic approach as might well be done at university level. The history, philosophy and sociology of science, for example, very rarely figure in school courses in a recognisable way, so the groupings supplied by Ziman, in Teaching and learning about Science and Society (1980) need to be slightly adapted retrospectively, and also given a school educational focus.

In place of the philosophy of science we find courses which use "ways of knowing" as the fundemental platform of their teaching. The argument here is that it is marriage of thinking and learning in a scientific way, with thinking and evaluating in a way appropriate for making social decisions, which gives these courses their special interest. Aikenhead and Fleming (1975) seem to have been the first to design such a course, and I hope that my own efforts in the SISCON-in-Schools project (1983) may be accepted as one of the same general species. The purpose of such elements of science education is not far to seek. Because they stress the skills necessary for the citizen's participation in democracy, it is clear that these form a part of the "science for all" movement. The justification for teaching this type of STS is that it educates a future generation of citizens, not just those who may become scientists or technoogists, for the process of decison-making. It is structural in that no special emphasis is laid on the facts of some particular issues, nor on the scientific and technological concepts which are involved. Examples of social issues are used throughout such courses, but they are not ends in themselves. The argument would be that all topical issues very rapidly become out of date. All that remains are appropriate ways of thinking, so this is where teaching should concentrate its efforts.

The vast majority of the prolific outpouring of STS materials which we have witnessed in the last few years have no such holistic pretentions. With few exeptions they do not produce complete courses but just additions to an existing science programme of study in a sense sometimes described as "filling the interstices". They take one topic at a time and treat it as a particular problem area, which enables different communities to teach about their particular issues in compact and readily handled packages. This selectivity is even be reproduced on a village or school scale which may make the issue look parochial to an outsider but certainly gives immediacy and relevance to the students' own work. At the other extreme materials may be produced which look to very large problems such as Nuclear Power or Nuclear Weapons, but still the approach is one of problematique, as Ziman (1980) called it.

There are several proposed educational justifications for this kind of work, over and above the interest and relevance of its materials. The units not only bring variety into the science curriculum, they also lend themselves to new ways of teaching using simulations, large and small group discussions, and "gaming". In as far as these activities promote skills not often in demand during science lessons, this category of STS broadens the learning method and contributes to a more holistic school experience. It may also be that it appeals more to girls than does traditional science teaching (Harding and Sutoris 1983). The question to be asked of this sort of work is that if it is only occasional within the normal teaching of traditional science how far will it teach or train students in these new skills, or "switch-on" - the term used by Jan Harding in her work on the science education of girls - those who do not usually find school science interesting.

Finally there is a third category in which this question of the whole nature of school science is tackled directly. The Dutch PLON Project, and the S-STS project at the University of Pennsylvania have both determined to develop science materials which are deeply imbued with the STS approach, and which are used to teach all the science content of one or more years of schooling. Here, they argue, there will be no conflict between the authoritarian face of "normal" school science and the essential negotiability of the STS approach. Clearly large funds and government backing are needed for such projects since their aim is no less than a change in the whole nature of science as it is experienced by school students. We can hardly be surprised, then, at how few of these syllabuses have actually emerged. It may be that the inaugurators of these courses use arguments from the modern sociology of science about the consensibility of knowledge. Nevertheless it does seem that their major justification is best stated in educational rather than academic terms. They believe that high school students would learn science better, both in the traditional sense of being better equipped with science process skills and knowledge, and in terms of the pleasure and interest that the students take in their studies, if science were presented in this totally new way.

Evaluation through research

The main purpose of our premliminary categorisation of STS courses by their educational intention is to assess what claims there are which educational research needs to examine. The lack of this research has often been bemoaned and the situation is only very slowly improving.

First we need a recapitulation of the claims being made by the different types of STS courses. They may be listed as follows:-

1. There is a need to differentiate between the different ways of knowing if students are to understand STS issues and make informed decisions.

2. The inclusion of more "relevant" topics increases the students interest in and enjoyment of science. (This needs to be extended to the effects on girls' interests and also the use of the different learning methods which are not often met in the normal science classroom.)

3. An STS course can be used for teaching the complete range of school science skills and concepts.

This identification of research needs will be followed, in my presentation, by a brief resume of the research results produced so far in each of the three categories. This will look particularly to the work of Fleming, Maple, Solomon, and the Assessment of Performance Unit.

Finally some new research will be reported based on responses from British eighth and eleventh grade students.

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SCIENCE AND SOCIETY IN THE SECOND IEA SCIENCE STUDY : AN ISRAELI PERSPECTIVE

by Pinchas Tamir, Hebrew University, Jerusalem *)

1 Introduction

In the first conference on world trends in science education which took place in Halifax in 1979, I discussed curriculum development and implementation and identified a number of future trends in science curricula. One of these trends was

> Science curricula will deal more with the interface between science and society and will attempt to build in students an image of science which is more congruent with current conceptions of historians and philosophers of science.
> (Tamir, 1980, p. 75)

In the last decade we have indeed witnessed a great number of efforts to increase the place of issues related to science and society in our classrooms and to make science education more relevant to the lives of students while they are in school as well as later on when they become adult citizens responsible for important decisions related to survival (Watson, 1980), economical development (Wanchoo, 1980) and personal everyday life (Aikenhead, 1980; Fensham, 1981; Hurd, 1982, 1985; Sood, 1982).

The Second IEA Science Study (SISS) was designed to assess the science achievement, attitudes, interests and preferences of students as related to the home, class and school enviroment as well as to the curriculum, instructional experiences and study habits. 26 different countries participated. Three student populations were involed as follows : Population I:10 years old, Population II:14 years old and Population III:17 years old.

Although science and society has not been the major focus of SISS it would have been a pity if such a massive effort would not be able to contribute some information on this important area.

Through careful examination and content analysis it was possible to identify particular items focusing on science and society in three intruments : the attitude inventory (ATT), the understanding of science measure (SUM) and the discription of science experiences (DES).

These items serve as the focus of the present study.

2 Purpose

The purpose of this study is twofold:

(1) To describe the attitudes toward and understanding of the relationships between science and society of Israeli students.
(2) To compare the Israeli data with corresponding data from other countries which participated in the Second IEA Science Study.

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3. Method

The major study population was senior high school (17 years old) students in Israel. Within the framework of SISS a variety of additional data was available regarding achievement in science, personal background and school variables. This information was used to find out how various factors such as socioeconomic status, gender, school environment, achievement and career aspirations are related to the data on science and society.

Some informations about science and society was available for 9th grade (14 years old) and 5th grade (10 years old). This data was used for comparison with the main study populations, thereby making it possible to identify developmental trends.

Lastly a letter was sent to the 25 countries participating in SISS requesting them to provide the raw data on the pertinent items from the three instruments (attitudes, understanding, experiences). This data served international comparisons.

The data was collected in the spring of the years 1983, 1984.

4. Findings

4.1. Attitudes

The Attitude Inventory contained 19 relevant statements. The respondent has to indicate whether he/she agrees (3), is undecided (2), or disagrees (1) with what is stated.

These items were submitted to principal components factor analysis with varimax rotation. Four factors were obtained (see Table I).

Results of varimax factor analysis of
Population III attitudes toward science and society
(N = 695)

TABLE I

No.	Factor/variable content	Loading
I	Science career and status	
13	It is important to know science in order to get a good job	.53
11	People who understand science are better off in our society	.49
8	In future most jobs will require a knowledge of science	.40
12	Public money spent on science in the last years has been used wisely	.32
25	People who work with modern inventions such as computers have more interesting jobs	.30
II	Science not harmful	
27	Science and technology are the cause of many world's problems	.63
20	Scientific inventions have increased tensions between people	.50
*24	Scientific discoveries do more harm then good	.39
10	Much of the anxiety in modern society is due to science	.36
* 3	Science has ruined the environment	.25
III	Science value to society	
16	The government should spend more money on scientific research	.66
* 5	Science is very important for a country's development	.45
7	Money spent on science is well worth spending	.40
*15	Scientific inventions improve our standard of living	.31
*22	Science will help to make the world a better place in the future	.31
* 1	Science is useful for solving the problems of everyday life	.27
IV	Science helps in everyday life	
55	Chemistry is important and useful in everyday life	.61
56	Physics is important and useful in everyday life	.56
54	Biology is important and useful in everyday life	.46

*Administered to Population I as well

As may be seen in Table I three of the factors, I,III,IV, are loaded with statements exhibiting positive attitudes toward science and society. Factor II is loaded with negative statements reflecting common views about the destructive and harmful consequences of science usually associated with pollution, dangerous weapons, anxiety and similar problems. It would have been designated as Science is harmful. However, since we wanted to maintain uniform meaning to scores so that a higher represents a more positive attitude we inverted the responses to the items in this Factor and, hence, it was designated as Science not harmful.
Table II presents the responses of the three populations to the Attitude Inventory.

Attitudes toward science and society of Israeli
students in the three populations

TABLE II

No.	Subtest and items	Population III N=695 A	$\bar{x}$	S.D.	Population II N=998 A	$\bar{x}$	S.D.	Population I N =2365 %
I	Science career	60	2.39	.44	49	2.24	.49	
	13	59	2.39	.80	54	2.32	.80	
	11	59	2.40	.79	40	2.02	.88	
	8	69	2.53	.78	48	2.26	.79	
	12	70	2.48	.83	48	2.31	.75	
	25	42	2.14	.81	55	2.33	.82	
II	Science not harmful	51	2.25	.47	51	2.29	.41	
	17	44	2.17	.81	45	2.21	.80	
	20	45	2.09	.89	39	2.11	.82	
	24	71	2.44	.88	67	2.59	.62	91
	10	18	1.94	.64	26	1.86	.80	
	3	76	2.60	.74	78	2.70	.61	91
III	Science value to society	74	2.56	.37	67	2.55	.36	
	16	50	2.12	.93	34	2.10	.75	
	5	97	2.95	.28	94	2.92	.33	82
	7	84	2.71	.68	64	2.56	.63	
	15	90	2.84	.51	90	2.86	.45	77
	22	49	2.11	.93	57	2.44	.72	83
	1	73	2.61	.74	63	2.42	.81	66
IV	Science help in everyday life	67	2.36	.61	82	2.75	.59	
	55 Chemistry	57	2.16	.85				
	56 Physics	64	2.39	.82				
	54 Biology	81	2.51	.81				

Item numbers correspond to those in Table I

For subtests I, III, IV: A = % Agree; 1 = disagree, 2 = undecided, 3 = agree
For subtest II A = % disagree; 1 = agree, 2 = undecided, 3 = disagree

It may be seen that the students have a very high appreciation for the value of science to society, to the country's development and to the improvement of the standard of living.
The data in Table II show that by and large the attitudes of 9th grade students are very similar to those of 12th grade students.

The following few differences are worth mentioning :
9th grade students have a higher appreciation for the help of scientific knowledge to everyday life and more of them believe that science will make the world a better place. Perhaps the longer life experience of 17 year olds made them realize that there are many problems in everyday life for which science has nothing to offer.

There are 5 items in which 12th grade students have more positive attitudes, 4 of which relate to science career and status: the older students are more cognizant of the potential of scientific knowledge for getting better jobs (items 11,8) and for problem solving (item 1). They are also more favourable to spending money on science (items 12,7). In spite of these differences the general similarity in the views of the two populations shows that the opportunity to study three years of sience in high school makes very little difference on views about science and society.
As to factor IV the differences between the three disciplines is striking. While 81% feel that biology helps in everyday life only 64% feel that way about physics and even less (57%) feel that way about chemistry. One wonders wether these differences reflect genuine characteristics of the disciplines or rather the way these subjects are taught in school. While there were no statistically significant differences between boys and girls in their perception of science as harmful or of its help in everyday life, substantial differences were found in the two other factors. The difference in Science value to society is about half a standard deviation and in Science career and status it amounts to 3/4 of a standard deviation. Apparently the boys' socialization toward science is stronger than that of girls, even when both groups represent, by and large, the science prone students who elected to specialize in science in high school.
Lastly students who have more positive attitudes toward science and society tend to choose science as a field of study at the university. Similarly students with more positive attitudes toward science and society tend to choose science oriented careers.

4.2 Understanding the relationship between science and society (percentages)

TABLE III
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Item no.	Subtest and item contents	12th Grade Israel N=940	9th Grade Israel N=1100	Age 11-14 Britain N=1200
A	Science and scientists	81	66	69
3	Science cannot show that lying is wrong	84	72	78
4	Science could never do without people with ideas	73	53	54
7	Education and support of science depends on people	83	72	78
9	Scientists are not responsible for the colors of the rainbow	84	65	67
B	Scientific research	69	66	46
13	Scientific research requires years of training	88	78	61
19	Results of scientific research are always good because they help mankind	44	60	24
20	Women are as good science researchers as men	76	61	54

Table III presents the results on understanding the relationships between science and society by two Israeli and one British populations. (This British data were taken from Coxhead and Whitefield, 1975.)

As could have been expected, with the exception of one item, the 12th grade students exhibit better understanding. Still many 12th graders hold views which are at odds with those accepted by scientists and philosophers. Thus, in item 3 16% believe that science can show that it is wrong to lie. These students apparently believe that science can guide us in moral judgment. Similary in item 9, 16% belive that scientists can change the colors of a rainbow. In item 4 the critical dependence of science on ideas is not recognized by 27% who assign higher value to money, equipment and research assistants. The important role of the people in supporting science education and scientific research has not been appreciated by 17% (item 7).
In item 19 only 44% believe that the results obtained by scientific research are always good. 35% prefer the distractor that the results "are sometimes bad since scientists are no better than people in other professions."
In item 20 about one quarter have not chosen option D thereby indicating their bias against the scientific integrity of women. The data in Table III indicate that as students become older their views on the relationship between science and society becomes closer to that of scientists and philosophers of science.
However, when we compare science and non-science majors at the 12th grade we find that the mean subtest scores of non-science majors are lower than those of science majors and are almost identical with those of the ninth grade students. Since the 9th grade population represents the whole cohort group, the apparent progress between 9th and 12th grade may be attributed to selection rather than to intellectual growth.
The comparison between Israeli and British data reveal some advantage to the British in understanding about science and scientists. On the other hand Israeli ninth graders have better understanding of the needs and outcomes of scientific research and are less biased against women.
Understanding the relationships between science and society was found to be related to a number of background variables. The findings may be summarized as follows :

(1) There are no significant differences between boys and girls.
(2) Students in the academic track have a better understanding of science and scientists.
(3) Students whose parents country of origin is in Asia/Africa have lower understanding of the relationship between science and society.
(4) Students with non-science career orientation have the lowest level of understanding. Surprisingly, the level of students aspiring for medicine is also low.
(5) Socioeconomic status as measured by the number of siblings, parents' education and number of books at home is significantly but not highly related to understanding the relationships between science and society.
(6) Positive correlations exist between understanding the science-society relationships, achievement in school science, effort invested in science study, liking of science, intentions for further study at the university and achievement in science.

4.3. Learing experiences related to science and society

Table IV compares the learning experiences related to science and society of 12th and 9th grade students.

TABLE IV

Frequency distributions, means and standard deviations of responses to 3 items of DES related to science and society

	Population III N = 680				Population II N = 1069			
Item	1	3	$\bar{x}$	S.D.	1	3	$\bar{x}$	S.D.
DES 12	15	28	2.13	.65	22	22	2.00	.67
DES 13	37	13	1.75	.67	41	9	1.68	.64
DES 17	67	3	1.36	.35	69	4	1.35	.55

1 = never 2 = sometimes 3 = frequently

The figures under 1 and 3 are percentages

DES 12 The teacher explains how the science we learn is relevant to our lives.

DES 13 The teacher discusses possible careers in science with us.

DES 17 We do field work outside the classroom as part of our science lessons.

The overall picture is that most teachers do very little in this area. At the 12th grade two-thirds of the students never do field work outdoors and only 3% do such work frequently. One-third report that their teacher never discusses possible science careers and only 13% have frequent discussion of that matter. Apparently most teachers do explain from time to time how the science taught in school in relevant to our lives, but only 28% do so frequently.

The data for Population II are very similar.

It may be concluded that in spite of the rich literature on the importance of incorporating issues related to science and society into school science, the available evidence indicates that this is never done by many teachers and rarely done by others.

It may have been argued that high school teachers are not devoting time to science and society because of the pressure of external examinations. However, 9th grade teachers are not under such pressure and still neglect this important theme.

4.4. Comparison with other countries

As already mentioned letters requesting pertinent data were sent to all the countries participating in SISS. Replies came back from 18 countries. Several countries have not analyzed their data. Some countries preferred not to release data before publishing their national reports. None of the countries which sent data had administered the Science Understanding Measure. Attitude data for Population II were received from 6 countries and for Population III from 4 countries. Data on learning experiences were received from 6 and 5 countries for the two populations respectively.

All the countries sent the percentage distribution for each item. Mean scores for individual items and for the subtests were calculated by this author. Since standard deviations for most countries have not been available, the comparison will be based on effect sizes. The effect sizes are calculated using the following formula:

$$\frac{\bar{x}_1 - \bar{x}_n}{S.D.1}$$

where $\bar{x}_1$ = means scores for Israel, S.D.1 = standard deviation for the Israeli sample, and $\bar{x}_n$ the mean score of any other country. A difference greater than 1/3 standard deviation is considered to be educationally significant (see Glass, McGaw and Smith, 1981).

4.4.1 Attitudes : Population II

Table V presents the results of 7 countries

Science career and status

Israeli students at age 14 have a relatively high regard for a science career. While American, English and Singapore students are similar to the Israelis, students in the other three countries are less positive, with the Netherlands occupying the lowest position. American and English students believe more than others that in the future most jobs will require a knowledge of science (item 8). Students in the Netherlands feel most strongly that public money spent on science has not been spent wisely (item 12), that it is not important to know science in order to get a good job (item 13) and that science based jobs are not more interesting (item 25). Israeli students hold the opposite position regarding these three items to which they express the highest agreement of all.

Science not harmful

On the average Singapore students have the lowest score while American students have the highest score. However the differences among most countries are rather small. Singapore and Netherlands students believe more than others that science has ruined the environment (item 3). Finnish, American and Israeli students are less inclined than others to agree that scientific inventions have increased tension among people (item 20). Israeli students agree more than others that, on the balance, science does more good than harm (item 24) and less than others that science and technology are the cause of many of the world's problems (item 27).

Science value to society

Here again the most negative attitudes are expressed by students in the Netherlands. Generally very few students in all the countries do not appreciate the value of science to society. The appreciation of Israeli students is especially high regarding the importance of science to the development of the country (item 5) as well as with regard to the contribution of science to the improvement of the standard of living (item 15).
In spite of the high appreciation, most of the Israeli students, like their counterparts in other countries, do not think that the government should spend more money on science (item 16).

Table V: Attitude toward science and society of Population II in different countries

	Israel N=998			Singapore N=4400		Britain N=3000		Nether lands N=4000		USA N=2000		Austra. N=5000		Finland N=2593		Mean of the 7 countries	
	A	$\bar{x}$	S.D.	A	$\bar{x}$	A	$\bar{x}$	A	$\bar{x}$	A	$\bar{x}$	A	$\bar{x}$	A	$\bar{x}$	A	$\bar{x}$
1. Science career and status	49	2.24	.49	47	2.22	45	2.12	29	1.87	42	2.14	37	2.00	29	1.98	40	2.08
08	48	2.26	.79	51	2.31	63	2.47	41	2.06	67	2.55	48	2.22	37	2.14	51	2.29
11	40	2.02	.88	45	2.15	35	1.97	36	2.01	43	2.16	33	1.91	19	1.83	43	2.01
12	48	2.31	.75	39	2.25	42	2.13	10	1.84	30	2.11	37	2.19	33	2.19	30	2.15
25	55	2.33	.82	65	2.48	44	1.97	34	1.54	42	2.08	37	1.92	32	1.94	44	1.84
2. Science not harmful	51	2.29	.41	39	1.95	41	2.11	46	2.14	54	2.35	39	2.12	46	2.27	45	2.18
03	78	2.70	.61	45	2.19	67	2.59	49	2.20	74	2.65	62	2.47	68	2.68	63	2.50
10	26	1.86	.80	17	1.67	32	1.96	41	2.23	34	2.10	32	2.09	52	2.26	33	2.00
20	39	2.11	.82	13	1.66	22	1.83	29	1.99	59	2.40	23	1.85	21	1.80	29	1.95
24	67	2.59	.62	50	2.36	48	2.32	48	2.29	63	2.55	51	2.35	53	2.45	54	2.42
27	45	2.21	.80	26	1.87	37	2.05	42	2.00	39	2.10	26	1.82	36	2.18	36	2.03
3. Science value to society	67	2.55	.36	69	2.58	59	2.42	57	2.14	66	2.47	58	2.39	53	2.36	61	2.42
01	63	2.42	.81	75	2.63	67	2.52	44	2.05	61	2.41	58	2.32	64	2.54	62	2.53
05	94	2.92	.33	84	2.78	77	2.70	71	2.57	86	2.81	75	2.64	71	2.65	80	2.72
07	64	2.56	.63	53	2.36	55	2.41	42	2.13	55	2.41	50	2.31	58	2.47	54	2.38
15	90	2.86	.45	86	2.82	76	2.70	41	2.18	80	2.76	79	2.71	60	2.24	73	2.61
16	34	2.10	.75	49	2.30	30	1.98	18	1.88	33	2.02	36	2.07	37	2.18	34	2.08
22	57	2.44	.72	67	2.56	46	2.24	29	2.01	59	2.27	48	2.28	29	2.11	48	2.27
4. Science related to everyday life	82	2.75	.59	74	2.68	61	2.49	43	2.15	63	2.50	55	2.36	58	2.44	62	2.48

A = % agree; 1 = disagree 2 = undecided 3 = agree

Science relevant to everyday life

Here Israeli students express a very high level of agreement, close to a half of a standard deviation above the mean of the seven countries and more than a whole standard deviation above the mean of the Netherlands' students. It may be concluded that at age 14 the attitudes of Israeli students toward science and society in all areas are more positive than the average of students from the six developed countries who participated in the study. They are most distinguished in their belief that science is important and useful in everyday life.

4.4.2. Attitudes : Population III

Table VI : Attitude toward science and society of Population III in different countries

	Israel N=695			Singapore N=3560		Papua N.G. N=488		Britain N=2600		Finland N=3600		Mean of 5 countries	
	A	$\bar{x}$	S.D.	A	$\bar{x}$	A	$\bar{x}$	A	$\bar{x}$	A	$\bar{x}$	A	$\bar{x}$
1. Science career and status	60	2.39	.44	40	2.09	39	2.06	41	1.97	39	1.86	42	2.07
08	69	2.53	.78	72	2.59	79	2.69	73	2.55	54	2.29	69	2.53
11	59	2.40	.79	46	2.09	29	1.73	46	2.04	22	1.72.	40	2.00
12	70	2.48	.83	34	2.15	16	1.89	35	2.02	23	1.86	36	2.08
13	59	2.39	.80	25	1.63	36	1.82	23	1.51	23	1.59	33	1.79
25	42	2.14	.81	26	1.72	47	2.17	28	1.75	21	1.81	33	1.92
2. Science not harmful	51	2.25	.47	38	1.09	36	1.89	55	2.35	62	2.41	48	2.18
03	76	2.60	.74	40	2.08	50	2.13	72	2.55	80	2.69	64	2.41
10	38	1.94	.64	30	1.84	37	1.93	59	2.35	74	2.64	48	2.14
20	45	2.09	.89	19	1.61	19	1.57	37	1.88	33	1.86	31	1.80
24	71	2.44	.88	56	2.47	47	2.18	80	2.74	75	2.69	66	2.50
27	44	2.17	.81	34	1.89	26	1.64	56	2.22	48	2.14	42	2.01
3. Science value to society	74	2.56	.37	72	2.61	72	2.56	82	2.74	69	2.57	74	2.60
01	73	2.61	.74	77	2.62	81	2.68	86	2.77	90	2.86	81	2.70
05	97	2.95	.28	94	2.90	81	2.69	97	2.95	85	2.78	92	2.85
07	84	2.71	.68	65	2.57	74	2.60	88	2.76	74	2.64	77	2.66
15	90	2.84	.51	92	2.89	84	2.71	92	2.88	75	2.66	87	2.80
16	50	2.12	.93	53	2.33	68	2.44	65	2.49	53	2.34	58	2.34
22	49	2.11	.92	52	2.38	46	2.14	61	2.58	34	2.06	48	2.25
4. Science relevant to everyday life													
Science	67	2.36	.61	70	2.52	71	2.56	68	2.48	55	2.22	66	2.43
Biology	81	2.51	.81	80	2.62	88	2.89	76	2.62	77	2.60	80	2.64
Chemistry	57	2.16	.85	54	2.28	56	2.28	58	2.28	41	1.99	53	2.20
Physics	64	2.39	.82	77	2.66	70	2.51	71	2.54	47	2.06	66	2.43

A = % agree; 1 = disagree 2 = undecided 3 = agree

Science career and status

Israeli students who major in one of the science subjects in year 11 and 12 have a very high regard for a science career, much higher than students in any of the four other countries. Only in one item which states that "in the future most jobs will require scientific knowledge" (item 8) there was no difference among the countries. In all other items the difference between Israel and other countries is about a half of a standard deviation. Thus it appears that the conditions in Israel and the Israeli culture are highly favorable toward science based careers.

Science not harmful

Students in Papua New Guinea and in Singapore see science as more harmful than students in Western countries. Israeli students occupy a middle position between the Eastern and Western countries.

Science value to society

On the average, the scores of all 5 countries are very high. In two items (16,22) Israeli students score lower than others. Thus, in spite of the value of science to society 50% of the Israeli students agree neither that the government should spend more money on scientific research nor that science will help to make the world a better place to live in.

Science relevance to everyday life

The science score in Table VI is an average of the scores obtaine for biology, chemistry and physics.
The most interesting result is the relative standing of the three science subjects: in all 5 countries biology is considered as the most relevant while chemistry is considered as the least relevant. In all the subjects the Israeli students' appreciation is somewhat lower than that of students in other countries.

4.4.3. Learning experiences

Table VII presents the results of 9 countries.

DES 12

Israel occupies a second place after Finland in both populations while the Netherlands and Japan hold the bottom position. Examination of Table V shows that at age 14 Israeli students indeed respond by expressing the highest level of agreement with the relevance of science to everyday life. On the other hand such an effect has not been found for Finnish students in neither population and not for Israeli students in year 12. Apparently by that age students can see the relevance by themselves.

DES 13

In this item Finland occupies again the first place leaving other countries far behind. In Population III Papua New Guinea holds the second place. Israel follows next in both populations. Interestingly in both populations Israeli students are much more oriented towards science careers than Finnish students and the same is true regarding Papua New Guinea in Population III.

Table VII

Learning experiences related to science and society in different countries

	Population II							Population III						
		DES 12		DES 13		DES 17			DES 12		DES 13		DES 17	
	N	1	$\bar{x}$	1	$\bar{x}$	1	$\bar{x}$	N	1	$\bar{x}$	1	$\bar{x}$	1	$\bar{x}$
Israel	1069	22	2.00	41	2.68	69	1.35	940	15	2.13	37	1.75	67	1.36
Australia	4970	31	1.81	63	1.35	42	1.60			Not Available				
England	3000	32	1.84	53	1.57	70	1.22	2560	28	1.83	55	1.49	59	1.44
Finland	2500	8	2.35	4	2.65	3	2.52	2600	8	2.36	3	2.65	1	2.88
Japan	6435		1.52		1.21		1.29	4260		1.69		1.54		1.20
Netherlands	3746	41	1.49	63	1.17	67	1.17			Not Available				
Papua N.G.			Not Available					479	15	1.99	7	2.23	5	2.15
Singapore	4400	22	1.97	44	1.67	69	1.65	3560	30	1.78	61	1.42	74	1.29
U.S.A.	2000	Not		Available		65	1.41			Not Available				
Mean			1.85		1.61		1.53			1.96		1.85		1.72

1 = Never 2 = Sometimes 3 = Often

DES 12	The teacher explains how the science we learn is relevant to our life
DES 13	The teacher discusses possible careers in science with us
DES 17	We do field work outside the classroom as part of our science class

5 Discussion

Three measures were used in this study : attitudes toward science and society, understanding the relationships between science and society, and school experiences related to science and society. For attitudes and school experience we had data from Israel as well as from other countries. For understanding the relationship between science and society we had data from Israel and from Britain. Since different subsamples responded to each instrument, it was impossible to study intercorrelations among the three measures.

5.1 Understanding the relationship between science and society

Although in general 12th grade students in Israel exhibit a high level of understanding several misconceptions have been identified.

a. science is not the solution for all problems in life. For example science, of course, cannot help us in moral judgment; and yet close to one-fifth of the students in grade 12 and 30% at grade 9 do not realize that, and expect science to show that it is wrong to lie;
b. science can explain natural phenomena but it does not create them; yet 35% in grade 9 and 16% in grade 12 don't see the difference;
c. science is the creation of people; yet about one half of the students in grade 9 and one quarter in grade 12 do not recognize the central role that peoples' ideas play in the scientific enterprise;
d. about one-third of the students believe that results of scientific research "are sometimes bad since scientists are no better than people in other professions;" these students do not realize that the personality of scientists has nothing to do with the results of their experiments;
e. lastly, 40% of the students in grade 9 and 25% in grade 12 reveal a definite bias again the competence and capability of women scientists.

These five misconceptions are quite serious and have important implications. The most obvious implication is the need to clarify issues pertaining to the role of people in the scientific enterprise as well as the epistemological differences between different domains of human knowledge, such as science and morality.

5.2 Attitudes toward science and society

In spite of many differences among the participating countries some common patterns have emerged.

1. In Population II Science relevance to everyday life achieves the highest rating followed by Science value to society, then by Science not harmful, and, last, by Science career and status. At the 12th grade, Science value to society has moved to the first place, replacing Science relevance to everyday life. In three of five countries, including Israel, Science career has replaced Science not harmful. Bearing in mind that most students in the 12th grade samples are those who have elected to study science, the changes between 9th and 12th grade can be a reflection either of selection or of maturation or of both.
2. Examination of the results related to the Relevance of science to everyday life reveals two other common patterns: (a) in most countries the 9th grade rating is higher than that of the 12th grade. This difference is especially conspicuous in Israel. Apparently the teaching of science in the upper secondary grades is more formal and less related to everday life than that which takes place in the middle school; (b) in all the countries, without exception, chemistry is regarding as the least relevant and (with Singapore as exception) biology is regarded as the most

relevant to everyday life. This finding may offer at least partial explanation for the relatively high enrollments in biology and low enrollments in chemistry. If we want to attract more students to chemistry and physics, as is the case in Israel, we may try to highlight the relevance of these subjects to everyday life.

3. Science not harmful consists of 5 items which received similar ratings in all the countries for both Population II and III. Thus, the majority of students do not think that "science has ruined the environment," neither do they feel that "scientific discoveries cause more harm than good." On the other hand most students in all the countries, including developing countries, such as Papua New Guinea and Singapore, do feel that "much of the anxiety in modern society is due to science" and that "scientific inventions have increased tensions between people." These views are held by the same students who regard very highly the value of science to society, who believe that "science is very important for a country's development" and that "scientific inventions improve our standard of living." It may be concluded that most students especially, 17 years olds, are mature enough to see both the benefits and the dangers of scientific discoveries.
4. Certain countries feature relatively low and others relatively high ratings in all areas. For example the ratings of the students in the Netherlands are the lowest in all subtests and in almost all items. It will be interesting to find out the reasons for these negative attitudes. In Population II Israel's ratings are higher than the international mean in all subtests.
   In population III Israel's ratings are the highest for Science career, somewhat higher than the international mean for Science not harmful and somewhat lower than that mean in Science value to society and its relevance to everyday life. In this study we have been able to correlate attitudes toward science and society with other variables only in Israel. Because of the common patterns just discussed we assume that many of the relationships identified for Israel may be valid for other countries as well.

Following are the major findings:

1. All four attitude scales are positively and moderately intercorrelated.
2. Attitudes toward science and society are positively but weakly correlated with achievement. The highest correlations are between achievement in physics and Science career.
3. Parents'education and the number of books at home are positively correlated with Science career. Students whose parents are scientists, engineers or doctors are more oriented toward science careers.
4. Students whose mothers work outside home are more oriented toward science careers than students whose mothers work only at home.
5. There are no differences between boys and girls in regarding Science as not harmful, or as relevant to everyday life. However boys have significantly higher appreciation for the value of science to society as well as a higher orientation toward a career in science.
6. Students who avoid science studies in the upper secondary school have substantially less positive attitudes toward science and society.
7. With the exception of Science not harmful, students in academic schools have more positive attitudes toward science and society than students in vocational schools.
8. Students who have more positive attitudes toward science and society tend to choose science as a field of study in the university and eventually also as a career, especially in engineering and the natural sciences.

5.3 Learning experiences related to science and society

Following the analysis of the Israeli data we concluded that:

1. Overall most science teachers do very little in this area.
2. At the 12th grade two-thirds of the students never do field work outdoors and only 3% do such work often.
3. One-third report that their teacher never discusses science careers and only 13% have frequent discussions of science careers.
4. Most teachers explain from time to time how science taught in school is relevant to everyday life, but only 28% do so frequently.

Examination of the data in Table VII shows that the situation is even worse in other countries with the exception of Finland and Papua New Guinea. Can we find some relationship between learning experiences and attitudes ? We cannot calculate correlations because we do not have the necessary raw data. However, it may be seen that in the Netherlands the ratings are the lowest for both attitudes and learning experiences. Unfortunately the high ratings of learning experiences related to science and society in Finland and New Guinea are not reflected in the students' attitudes. If the findings just reported for Finland and Papua New Guinea can be replicated, they would have serious implications since they cast doubt about the desirability of spending much class time in discussing possible careers in science and on the effect of outdoor studies on the development of positive attitudes toward science and society.

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7 A biographical note

Pinchas Tamir is a Professor at the School of Education and the Israel Science Teaching Center, Hebrew University, Jerusalem. He received his Ph.D. at Cornell University in 1968. Since 1969 he has been the Director of the Israel High School Biology Project. He has published numerous chapters in books and more than 150 research papers in science education, curriculum and other education journals.

His research deals with topics such as curriculum, evaluation, teacher education, instruction, and various aspects of science education. He is the recipient of the 1977 Palmer O. Johnson award of the American Educational Research Association for the best research paper. He served as visiting professor in Australia, Mexico, Canada, Norway, and a number of universities in the USA.

THE IOWA STS PROJECT:
STUDENT GROWTH IN A VARIETY OF DOMAINS

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Science as taught in grades 4 through 9 (ten to fifteen year-olds) has been identified as the most critical issue in school science in the State of Iowa. These grades are ones where science is required for all students and are ones where the teachers are often ill-prepared, i.e. with little science preparation and no focus on a particular discipline of science. This means that the teachers of these grades often want help and do not have preconceived notions of what "must be included" in a course as is often the case for high school biology, chemistry, or physics.

In 1984 the National Science Teachers Association (NSTA) was awarded a major grant to conduct a series of Chautauqua Short Courses in sixteen states; Iowa was selected as one site. Three NSTA Yearbooks have focused on STS education; the NSTA Position Statements for the 80s (NSTA Position Statement, 1982) emphasized the importance of STS:

> The goal of science education during the 1980s is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision-making. Such individuals both appreciate the value of science and technology in society and understand their limitations.

NSF also funded a major project at Pennsylvania State University called Science through Science/Technology/Society (S-STS). This project was funded to foster further STS experiments, to assess curriculum materials, and to encourage evaluation of STS efforts. Leadership in Iowa was involved with the S-STS efforts, including identification of features of exemplary STS programs, promoting awareness of STS, and assessing the impact of STS efforts on students.

Iowa became a center for the NSTA Chautauqua program and for S-STS networking. One aspect of this "center" designation was selecting teachers who were willing to learn about STS, to try STS modules in their classrooms with students, to collect evaluation information, and to interact with others concerning their experiences. The first year (1984-85) but 30 teachers from grades 4 through 9 were involved. However, at the close of the first year the Iowa Utility Association became interested in the effort and agreed to support two additional workshops in addition to the one to be supported by NSTA during the 1985-86 year. A total of 90 more teachers (and schools) were involved with the Chautauqua program during 1985-86. The successes of this effort encouraged further expansion of the program for 1986-87 and the abandonment of the separate NSTA and IUA Workshops. During 1986-87 120 new teachers were involved. Plans for 1987-88 have been completed when in excess of 150 teachers will be served.

The Iowa Utility Association has assumed major support, approximately 80 percent of the total cost. Leadership conferences for 15 teachers are held for two weeks during the summer for teachers who will become staff members for the program during the next academic year. Annual fall conferences have been established for the past participants and educational leaders of the state. Other industries in Iowa have agreed to help with support for this conference and for making awards to teachers and schools with the most impressive STS projects/programs.

In an effort to define STS projects for the Iowa Chautauqua program, the following features were advanced:

1) identification of problem with local interest/impact;
2) use of local resources (human and material) to locate information that can be used in problem resolution;
3) active involvement of students in seeking information that can be used;
4) science teaching going beyond the class period, the classroom, the school;
5) a focus upon personal impact—perhaps starting with student impact—not hoping to get to that level;
6) a view that science content is not something that exists for student mastery simply because it is recorded in print;
7) a de-emphasis upon process skills—just because they represent glamorized skills of practicing scientists;
8) a focus upon career awareness—especially careers that students might expect to pursue as they relate to science and technology;
9) students performing in citizenship roles as they attempt to resolve issues they have identified;
10) science study being visible in a school and in a community;
11) science being an experience students are encouraged to have;
12) science with a focus upon the future and what it may be like.

Further every teacher participant agreed to try an STS unit for at least two weeks with the possibility that they could revamp their entire science course for the year. Some of the NSTA exemplary STS programs (Penick, Meinhard-Pellens, 1984) were identified as models for the participants. The NSTA criteria for excellence for STS programs and the Focus on Excellence volumes were made available to each teacher.

A total of 240 Iowa teachers have now participated in the STS Chautauqua program; many of these teachers continue to expand their efforts and to devote more time to STS materials and approaches. All continue to provide feedback both anecdotal and in terms of more formal assessment instruments.

The introduction to STS has included suggestions for evaluation. Science is defined as George Gaylord Simpson (Pittendrigh, C.S. & Tiffany, L.H., 1957) envisions it, namely:

> Science is an exploration of the material universe in order to seek orderly explanations (generalizable knowledge) of the objects and events encountered: but these explanations must be testable.

Science is first of all an exploration of the universe. It requires a personal curiosity—a wonderment for the world around us. Basically, all people are curious—some more than others. Unfortunately, the typical school seems to discourage such exploration. Hence, the school program can be seen as discouraging the first feature of real science.

The second ingredient of science is the attempt to explain the events and objects encountered during exploration. The formation or creation of such explanations is essential for science to occur. It is a phenomenon that is discouraged in most school curricula—especially in the traditional science programs. Again it seems that common practice is alien to the basic nature of science.

The third and final feature of science is the testing of the explanations formulated. Explanations—to be science—must be testable. It is possible to offer all kinds of explanations—creative ones, ones dependent upon the supernatural, ones that defy experimentation. Such explanations may be appropriate for other human enterprises such as creative writing, art, religion, etc. However, if an explanation of events and/or objects arising from explorations of the universe cannot be tested for their validity, there can be no science experience.

Science education is conceptualized as an enterprise that includes five domains. These include the following:

Domain I - Knowing and Understanding (knowledge domain)

Science aims to categorize the observable universe into manageable units for study, and to describe physical and biological relationships. Ultimately, science aims to provide reasonable explanations for observed relationships. Part of any science instruction always involves learning by students of some of the information developed through science.

The Knowing and Understanding Domain includes:

Facts
Concepts
Laws (Principles)
Existing hypotheses and theories being used by scientists.

All of this vast amount of information is usually classified into such manageable topics as: matter, energy, motion, animal behavior, plant development.

Domain II - Exploring and Discovering (process of science domain)

Use of the processes of science to learn how scientists think and work. Some processes of science are:

Observing and describing
Classifying and organizing
Measuring and charting
Communicating and understanding communications of others
Predicting and inferring
Hypothesizing
Hypothesis testing
Identifying and controlling variables
Interpreting data
Constructing instruments, simple devices, and physical models

Domain III - Imagining and Creating (creativity domain)

Most science programs view a science program as something to be done to students to help them learn a given body of information. Little formal attention has been given in science programs to development of students' imagination and creative thinking. Here are some of the human abilities important in this domain:

Visualizing - producing mental images
Combining objects and ideas in new ways
Producing alternate or unusual uses for objects
Solving problems and puzzles
Fantasizing

Pretending
Dreaming
Designing devices and machines
Producing unusual ideas

Much research and development has been done on developing students' abilities in this creative domain, but little of this has been purposely incorporated into science programs.

Domain IV - Feeling and Valuing (attitudinal domain)

In these times of increasingly complex social and political institutions, environmental and energy problems, and general worry about the future, scientific content, processes, and even attention to imagination are not sufficient parameters for a science program. Human feelings, values, and decision-making skills need to be addressed. This domain includes:

Developing positive attitudes toward science in general, science in school, and science teachers
Developing positive attitudes toward oneself (an "I can do it" attitude)
Exploring human emotions
Developing sensitivity to, and respect for, the feelings of other people
Expressing personal feelings in a constructive way
Making decisions about personal values
Making decisions about social and environmental issues

Domain V - Using and Applying (applications and connections domain)

It seems pointless to have any science program if the program does not include some substantial amount of information, skills, and attitudes that can be transferred and used in students' everyday lives. Also, it seems inappropriate to divorce "pure" or "academic" science from technology. Students need to become sensitized to those experiences they encounter which reflect ideas they have learned in school science. Some dimensions of this domain are:

Seeing instances of scientific concepts in everyday life experiences
Applying learned science concepts and skills to everyday technological problems
Understanding scientific and technological principles involved in household technological devices
Using scientific processes in solving problems that occur in everyday life
Understanding and evaluating mass media reports of scientific developments
Making decisions related to personal health, nutrition, and life style based on knowledge of scientific concepts rather than on "hear-say" or emotions.
Integrating science with other subjects

The most important domain for STS efforts is the applications/connections domain. In fact, it is this domain which is offered as the one which is most appropriate for all people—since it is closer to the total society of which all are a part. The applications of science are basic to the lives of people including communication, transportation, nutrition, shelter, clothing, careers, entertainment—literally all aspects of the human existence known by all.

Some time is spent concerning the arguments of Morris Shamos that science (as Campbell defines it) is inappropriate for most and cannot be justified as basic (i.e. required) for all learners in schools (Shamos, 1982; Shamos, 1983; Shamos, 1983/1984; Shamos, 1984a; Shamos, 1984b; Shamos, 1985).

Shamos would argue, however, that a better case can be developed for all people understanding technology as opposed to science.

The point is made that a focus on the acquisition of knowledge first may be the major problem with most science teaching. It may be faulty logic to argue that students first must be given knowledge before they can hope to apply it. Perhaps instead basic science knowledge can be seen as useful as questions arise and as more experiences accrue as students work in the application domain. Figure 1 is an attempt to illustrate the Iowa plan for STS instruction and evaluation.

Not all of the 240 teachers involved to date have provided assessment information in all domains. All have provided information regarding change in knowledge acquisition, the affective domain, and one instrument in the application domain. All are encouraged to try one or more measures (or some simple adaptation of selected items) from the process and creativity domain.

The instruments used in the Iowa STS Project include:

Domain I = Knowing and Understanding (knowledge domain)

1) Science Subtest, Iowa Tests of Basic Skills (Hieronymus, et al)
2) Science Subtests, Iowa Tests of Educational Development (Feldt, et al)
3) Science Subtest, Metropolitan Achievement Tests (Prescott)
4) Science Subtest, California Achievement Tests (Blackwood)
5) Chemistry Achievement Examination (ACS-NSTA)
6) Physics Achievement Examination (AAPT-NSTA)

Domain II = Exploring and Discovering (process of science domain)

1) The Methods and Procedures of Science: An Examination (Woodburn)
2) Test of Inquiry Skills (Fraser)
3) Wisconsin Inventory of Science Processes (Welch)
4) Cedar Rapids Schools Science Process Measure (Phillips)
5) ERIE Science Process Test (Wallace)

Domain III = Imagining and Creating (creativity domain)

1) Purdue Creativity Test (Lawshe, et al)
2) Torrance Tests of Creative Thinking (Torrance)
3) Modes of Thinking in Young Children (Wallach, et al)

Domain IV = Feeling and Valuing (attitudinal domain)

1) Student Preferences and Understandings (NAEP)
2) Scientific Attitude Scale (Moore)
3) Attitude toward Study of Science (Yager)
4) Test of Attitudes on Technology-Society Interaction (Piel)
5) Attitudes toward Science and Technology (Temple University)

Domain V = Using and Applying (applications and connections domain)

1) Science and Society (Dagher)
2) Views on Science-Technology-Society (Aikenhead)
3) Test on the Social Aspects of Science (Korth)
4) STS examination items for Science in a Social Context (ASE)

The results in the knowledge area have rarely shown any differences in the acquisition of the knowledge sampled—either on teacher tests or standard examinations (Kirkpatrick & Yager, 1986; Krajcik & Yager, 1986). Many of the

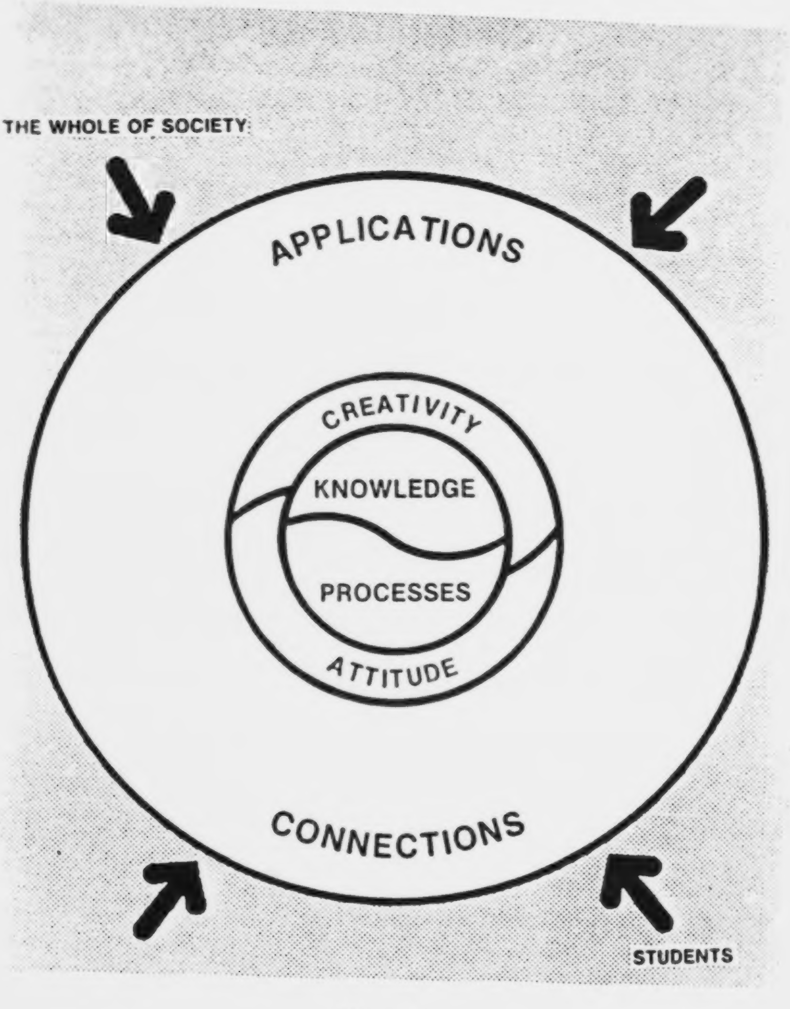
THE WHOLE OF SOCIETY:
APPLICATIONS
CREATIVITY
KNOWLEDGE
PROCESSES
ATTITUDE
CONNECTIONS
STUDENTS

Figure 1.

teachers have reported that many students actually do better on standard examinations than when they proceed through the textbook and the typical daily lessons. They report that more students are motivated and that more see the value of the knowledge that was merely offered for its own sake previously and/or with the promise that they would find the information useful in the future.

The results in the affective domain have been dramatic. Students experiencing science in the STS format have more positive attitudes concerning science teachers, classes, and careers. They have more realistic views concerning the utility of science study. And, of most importance, these attitudes are maintained across grade levels (Simmons, P.E. & Yager, R.E., 1986; Yager, R.E.; Simmons, P.E.; & Penick, J.E., 1987a, 1987b).

Since most typical science classes never consider technology (applications of science) or attempt to connect the knowledge/process exposure/acquisition to real-life situations, it is not surprising to find that the STS students and classes perform better than students who experience traditional science. Many students who have not had STS experiences cannot see why questions in this domain are even being asked of them (in contrast to the situation when students with STS experience are assessed in the knowledge domain).

The Iowa STS Project permits the following generalizations after three years of effort and the involvement of 240 teachers from grades 4 through 9:

1) Students who experience science in an STS format for a semester or longer acquire as much basic knowledge of science (as measured by standardized and teacher-made examinations) as do students who experience science in a more standard (textbook) way.
2) When teachers stress student experience with a variety of processes of science, students grow in this domain in both the STS and the standard course format.
3) Students who experience science in an STS format are far more positive in terms of their attitudes about science, science classes, science teachers, science careers, and the value of science to themselves; further, these positive attitudes are maintained over several grade levels.
4) STS programs apparently do more to enhance creative thinking than do standard science courses; unfortunately, measurements in the area of creativity are more difficult and there has been little opportunity to study the apparent growth over grade levels.
5) Students who experience science as STS can take actions, make decisions, use information, and are more curious than students who experience science primarily as a matter of acquiring certain basic concepts included in typical courses and textbooks.

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IONIZING RADIATION AND ENVIRONMENTAL POLLUTION - A THREAT TO BIOTIC LIFE

by

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The earth today supports an estimated ten million species of plants and animals. The great variety of living organisms is the result of three billion years of evolution. Till recently it was assumed that the generation of new species kept pace with the extinction of old ones. The destruction of old species by man has assumed such alarming dimension in the last few decades that an estimated 25.000 species of plants and more than 1.000 species and sub-species of animals are threatened with extinction. It is believed that more than a million species would become extinct by the end of this century.

Man is said to be the product of heredity and environment. However, seriously the biologists may debate the relative importance of roles, these two factors to play in the development of mental and moral traits and of characters are well established. It is quite plain, as regard to physical health and well-being, there is no hereditary endowments.

The great biologist, Herbert Spencer spoke of life as being characterised by a continuous adaption of function to environment. Infact, there seems to be no limit to life adaptability in environmental conditions. The sperm whale in the depths of the arctic sea and the bird of paradise in the tropical forests are merely suggestive of these possibilities. The actual physical environment is made use of a multitude of separate units viz., temperature, air, water,nutrition.

Radiation from the sun is the starting point for the most physical systems on the earth's surface. Radiation from the sun heats the atmosphere and the earth's surface. It is a source of energy for moving the great currents of air around the Globe. These, in turn, make the heat from radiation more equitably distributed over the earth, so that, a large part of the planet has temperatures in a range inhabitable for human beings. As an energy source for evaporating water, radiation drives the hydrological cycle for the earth thus providing through precipitation a continually renewed source of fresh water for the world's agriculture and life. Another vital aspect of radiation from the sun is it's role as an energy input to ecosystem, through the Bio-chemical process called photosynthesis, solar energy is changed into the chemical energy of plants that are later consumed by humans and other animals to sustain life. Radiation is also important at the scale of an individual, as we are being continuously bombarded by flows of radiation from our surroundings such as walls, sky, sun, trees and at the same time our body is radiating away heat energy, so as to prevent us from becoming too hot. In this manner our body temperature would be controlled by the difference between incoming and outgoing flows of radiation. This difference is called the Radiation balance.

The health effects of low-ionizing radiation on human populations have been difficult to establish. The effects of low-level ionizing radiation on somatic and genetic risks are now a known facts.

Somatic effects of ionizing radiation indicates, that children born after their mothers had 1-6 pelvic radiagraphs were about 42% more likely to die of cancer in the first ten years of life than were children not irradiated in Vitro.

Excess childhood leukemia in Southern Utah appeared to be associated with fallout from above-ground nuclear weapons tests in Nevada between 1951 to 1958. The leukemia mortality percentage is high for children living in high fallout countries as compared to controlled children from before and after test period. The implications of this for the nuclear industry and present radiation safety standards are serious. In addition to causing increased risk for various cancers, low level ionizing radiation may be implicated in excessive risk of death from heart disease.

There have been few studies of genetic or preconception effects of exposure to low-level ionizing radiation in human populations. Genetic effects have been sought and could most obviously have been expected in the off-spring of atomic bomb survivors. This may be due, among other factors, to masking of mutations, delayed expression of them, incomplete data on spontaneous abortions, populations in areas with higher than usual background radiation have been investigated for the presence of chromosomal aberrations and developmental anomalies. The former have been found in high radiation areas in the state of Kerala, India. In Kerala villages with high background radiation - (1500 - 3000 mr. Yr-1). Down's syndrome and mental retardation were markedly more prevalent than in villages with lower radiation (ca. 100 mr. Yr-1). The two populations- 12.918 and 5.938, respectively were similar with respect to an array of variables, but the prevalance of severe mental retardation of genetic origin was four times higher in the study than in the control population. After the incident of Chernobyll, Philliphine has banned the import of milk and milk products from Holland as they contain radio-active particles.

An important act of differentiation is the influence of the external environment, which can frequently modify the profoundly development of an organism. This particularlyevident in plants. How the environment influences gene activity is not understood. This is evident that, Anthocyanin is formed only in parts of the plant exposed to sunlight.

The biological effects of ionizing radiation was recorded in China by examining 150.000 Han peasants with essentially the same genetic background and same life style. Half of them lived in a region where they received an almost threefold higher radiation exposure because of radio-active soil. More than 90% of the progenitors of the more highly exposed group had lived in the same region for more than six generations. The investigation included the determination of radiation level by direct dosimetry and evaluation of a number of possible radiation related health effect including chromosomal aberrations of peripheral lympocytes, frequencies of hereditary diseases and deformities, frequency of malignancies growth and development of children, have demonstrated that excessive radiation at moderate dose-rates leads to shortening of life primarily due to corcinogenesis.

The tropical forests probably harbour thousands of organisms of great potential used as sources of food, fuel, fibre and drugs. With the large scale extinction of these forests, many species of great economic potential are being lost.

Another aspect of ecosystem preservation is that the vast scope, it offers for the evolution of new crop varieties and genetic material strong and vigorous enough to face the emergence of new pests and diseases which threaten to undermine the progress achieved in agricultural production, not only does every species has its unique set of biological, there is also considerable diversity among the individuals of a given species. This genetic diversity within a species constitutes the new material on which is based the generation of new high-yielding strains of cultivated crops and domesticated animals. It is seen by experience that these new high yielding strains have become the target of attack by insect, nemetodes, bacteria, fungi. A continuous search is needed for newer and newer genetic abilities in the crops to overcome the perennial challenge of evolving pests. The raw materials for this can come only from the indigenous strains of the cultivated plants.

Each minute, India is loosing 10 hectares of land in the form of soil erosion, salination and urbanisation. These efforts mainly focussed on soil conservation and afforestation. By AD 2.000 the population of India would be one billion and a serious short fall of food grain arises, if the agricultural land is not properly maintained. The major rivers of India are highly polluted with 238 major Industries pouring 90.000 million tonnes of effluents into the rivers. Underground water level receeds to an alarming level and as a result all the lakes in the country are suffering from a slow process of death. Due to cutting of grass in the hill regions, over 60.000 million tonnes of top soil was being washed into the sea every year.

Although many of the environmental problems which the developing countries encounter are traceable to poverty and population, related factors are, congested habitat, unclean living conditions, unprotected water supply, the damage industrial effluents cause to human life. The Bhopal tragedy, the worst industrial disaster provided a living example of air pollution following a deadly gas leak, there are any number of cases of water ways having become poisonous on account of industrial units discharging highly toxic substances into them. For example: Chemical wastes released from factories are said to account for 13% of Ganga's pollution, the figure touches 50% at certain points. At Kanpur, over 150 units dump their effluents into the river. The contaminated water of Sabarmati river in Gujurat is spurned by the cattle, while a polluted 60 Km stretch of Tungabhadra in Southern India is reported to have destroyed the bulk of fish population. The pollution of ground water by Tannery effluents has reached alarming levels. A survey of water polluting industrial units identified about 4.100 factories of both large and medium sectors in India, that cause a major health hazarduous.

The living organism is a bio-chemical factory of tremendous potential. A bacterium, during its life time can produce more chemicals than man can produce in all the chemical laboratories on the planet. Each species of living organism produces something unique, something not produced by any other organism. The magnificant mould penicillium an antibiotic has revolutionised man's ability to fight diseases. Since then, Armadillo, an arcance mammal of America is the only other animal besides man, now known to counteract leprosy. The chemical fertilizers using by farmers indiscriminately in developing countries, cause to inactivation of azotobactor- a nitrogen fixing bacterium in the root nodules of leguminusae plants that enriches the nitrogen contents of soil, that destroy the micro-organic fauna of soil responsible for healthy maintenance of natural vegetation.

Highly productive lands slowly lose their ability to sustain vegetation and in the process the ecology of the area become upset. The degree of degradation varies with the intensity of human interference ranging from farm lands of declining productivity to barren desert lands. Annually about 2.5 million hectares turn into waste lands in India besides, 1.5 million hectares become barren due to deforestation alone.

India had a forest area of 46.35 million hectares in 1981 which is far below the estamates of Central Forestry commission (75 million hectares). The forests in Himalayas have suffered seriously as a result, environmental problems have cropped up. The soil on the hill top has been subjected to erosion and the fragile eco-system is breaking under pressure.

Efforts are now being taken to preserve the eco-system and biotic life by the department of environment, Government of India. The man and Biosphere (MAB) programme launched by the Government, aims at conserving as much of the biological diversity in India as possible and forms part of the International scheme to set up a global net work of biosphere reserves. The idea of biosphere reserve was initiated by the UNESCO in 1973-74, under the MAB programme and the first reserve was established in 1976. Since then, the net work of international biosphere reserves has grown and in 1984, there were 243 reserves in 65 countries. Following the first International biosphere reserves conference held at Minsk in 1983, an action plan was drawn up with the co-operation of the UNESCO, FAO, UNEP and IUCN.

The evidence for climatic modification due to man's activities has increased dramatically over the last decades and the impact will accelerate in the near future. Climatic modification is first felt, because of the global nature of the earthatmospheric energy exchange system and the hydrological cycle.

The principles of the radiation balance based on potential large-scale impacts involve; water diversion schemes for hydroelectric generation, irrigation, forest removal, intensified agriculture and live-stock herding and increased urbanisation agglomerates atmosphere changes in carbon dioxide and dust contents.

In a hungry search for hydro-electric power and water for irrigation many of the world's rivers have been disturbed by constructing dams across them and create artificial lakes and that by early twenty first century, all of the world's rivers with any potential for power will have dams across them. In India by 1982 there were 53 dams covering approximately fourteen thousand sq.Kms of land in flooding. Land in low latitude increase the net radiation providing, more energy for water evaporation into the atmosphere. In the middle and high latitudes, the creation of artificial lakes imposes climatic effects which are tied to the seasons.

Albedo of the earth-atmospheric system so that the greater loss of sunlight to space leads to atmospheric cooling. This creates a stable atmosphere in which the cooler air subsides. Stable air, in turn, does not have the turbulent mechanisms for condensation and precipitation. The air borne dust has accentuated the drought.

A city generates its own distinctive climate. The important differences in comparison to its rural surroundings are shown in the table below:

Climatic differences between urban and rural areas.

Elements	Comparison with rural environment	
	More	Less
Dust particles	10 times	-
Gases	5.25 "	-
Precipitation	5-10%	-
Temperature	0.5-1.0°C	-
Solar Radiation	-	15-20%
Albedo	-	50-100%
Windspeed	-	20-30%

SOURCE : - Landsberg (1962).

High evoparation certainly increases rainfall and snowfall in the autum and early winter.

Forest destruction represents a surface modification which lasts a considerable period. Rouse (1976) reports that burning of the subarctic forest near the tree line in North-Western Canada results in a 10 to 15 percent reduction in, summer time, net radiation and a more arid environment, with drier and warmer soils results in reduced evapotranspirations. Forests removal results in substantial changes in the energy and water balances of a surface and in the availability of soil moisture. The removal of forests in the wet tropics appear to create irreversible changes in the humus layer provided by the forests. Attempts to convert these areas into agricultural lands destroys the humus layer and transforms the soil into an impervious laterite with a small soil moisture storage capacity. This effectively prevents the re-establishment of tree-growth. In Rajasthan desert of North West India, overgrazing by goat herds has allowed erosion to place large amounts of wind, borne dust in the atmosphere.

As a sequel to the enactment of the Environment (Protection) Act 1986, Govt. of India has drawn up a comprehensive programme for implementation of new Act, through extensive survey and research on the current situation, involvement of 150 Universities foe environmental impact assessment, measures to prevent environmental degradation and creation of an awareness among all the sections of the society including central/state pollution boards and various inspectorates.

If the measures to protect environment were not taken up on a war-footing, our planet would be bereft of trees, in 20 years time. India at present rate loosing the forest cover of one and half million hectares every year and the situation was fraught with serious consequences of humans as well as animal survivals.

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EDUCATIONAL SYSTEM

Pre-University Education or 10 + 2 standard is a course introduced in India soon after the schooling and the student will enter the course at the age of 16. The duration of the course is for two years, having Arts, Science and Commerce faculties. Candidate may choose any one group as his optionals for his studies. The course is run by a seperate Pre-University Board and after the completion of this course, the candidate is eligible for admissions into degree classes of relative subjects; students desirous of seeking admissions into Technical/Professional degree courses like Engineering, Medicine, Pharmacy, Dentistry, Law etc., should have obtained at least 50% of the marks in the theory examinations of relative obtional subjects in the second year terminal examination, which qualifies him to take entrance examination. The successful candidate will have to appear before a board of experts for final selection.

The impact of Radiation and Environmental pollution is of manifold in nature on biotic life, more particularly on human life. In recent times an awareness is created to abate health hazarduous and to save the next generations. Government of India, Universities and other study and research centres have taken measures to introduce Environmental studies as one of the branch as a regular curriculum from pre-university level. The present paper will help as a guide line to frame the syllabus and sort out the relevant chapters for studies in pre-university and degree levels in Indian schools and Colleges.

Biographical notes

Dr. G.C. Bhyraiah is a B.Sc., (Hons) graduate in Botany and obtained M.Sc., degree from Mysore University (S.India), taught General Botany, Cytogenetics and Ecology for degree cources for 18 years and cytogenetics for postgraduate courses for 8 years, obtained Ph.D., in Biometrical genetics : conducted research on cytogenetics and plant breeding in the genus Crotalaria Linn, and effct of Industrial pollutents in chromosomal aberrations. Published several papers and attended quite a few National / International Seminars / Conference on Science, Education and Technology, delivered lectures in various Universities on present day topics concerned to biological Sciences.

Elected as a permanent member for;

1) Indian Institute of Public Administration.
2) New York Academy of Sciences.
3) International society for tropical Ecology, presently hold the position of Director, College Development Council in the University of Mysore.

SCIENCE EDUCATION AND THE SCIENCE OF NUCLEAR TECHNOLOGY. ITS CONTROVERSY AND IMPACT ON DEVELOPING SOCIETIES

Dr. I.T. Eshiet (University of Cross River State, Uyo; Nigeria)

ABSTRACT

In recent times, sectorial pressures have built up in some developed countries on the need to reduce if not completely dismantle nuclear weapons. The risks are obvious. Not much however is known of any mass movements on this compelling need. The larger society, especially in the third world is ill-informed. This paper seeks to establish the need for educating the society on the dangers of nuclear fall-out as a part of our Science Education and Society Programmes. Information on preparedness to manage radiation victims is sought from practicing medical personnel through a questionnaire. The responses show that our medical units are ill-prepared to handle radiation cases.

INTRODUCTION

The change to peaceful uses of nuclear energy as is seen in the technology of nuclear fuels for the production of electricity ushered in a sigh of relief to the disturbed population who all along had raised objection to the continued military uses of nuclear power. But although the propaganda on peaceful development wages on, many nations, especially the super-powers are stockpiling nuclear arsenals. Worse still are the dangers of accidents that could occur in nuclear plants as known to have occurred in recent past. Not much is heard of or known about the technology of nuclear weapons in the third world especially in black African countries excepting South Africa, but the dangers of nuclear fall-out are not limited to the boundaries of the country of origin. In an event of the deployment of nuclear weapons or an accidental damage to a nuclear plant close enough to a third world country, how protected are the populace from the fall-out?

Tewari (1984)[1] observed:

> A report counts above 50,000 nuclear warheads in the world today corresponding to 3.5 tons of TNT for every human on the earth. This combined with chemical, biological and laser devices is more than enough for the annihilation of all forms of life.

A careful examination of the General Studies (Science) programmes in six Nigerian Universities shows that although environmental pollution is a course in each programme, nothing is taught on safeguards and protection of the populace against dangers of a nuclear fall-out. It was then felt that perhaps the answer to this could be found by interviewing medical practicals who are in a position to handle victims of radiation and accompanying effects of a fall-out.

SIGNIFICANCE OF THE STUDY

Current and past publications on Science Education and Society do not give consideration to radiation effects on the population in the area of Environmental Education. With increasing tendency for nations to develop nuclear energy and the obvious threat to life and the survival of the human race, there is the need to educate the society on the dangers of nuclear fall-out. The International Organisation of Science and Technology Education (IOSTE) has a duty in this respect. Other organisations such as the British Medical Association (BMA)[2] and Medical Campaign against Nuclear Weapons[3] are mounting campaigns against the development and deployment of nuclear weapons. In my opinion, the third world countries are likely the most ill-prepared and consequently the most ready victims of a fall-out. As Richmond (1983)[3] observed:

> In the Third World, countries apparently outside the East-West confrontation remember Horishima and wonder if they could be the 'trial run' for the new generation of weapons.
>
> In Britain, the newly-formed Medical Campaign against Nuclear Weapons has joined forces with the Medical Association for the Prevention of War which was founded in 1951 at the peak of the cold war. Together, they are struggling to make the British public aware of the medical effects of nuclear weapons .... In matter-of-fact language, the report sets out the devastating consequences and medical problems after nuclear war.

If the society is made to know the environmental dangers of developing nuclear energy and weapons, it would be possible to influence the need to reduce its development and deployment.

STATEMENT OF THE PROBLEM

To what extent are practicing doctors in the third world equipped to manage radiation patients in event of a nuclear fall-out?

PROCEDURE

A twenty-three item questionnaire ranging from practice experience to knowledge of subject matter was distributed to medical practitioners in the Cross River State of Nigeria. Thirty-two doctors completed and returned the questionnaire.

LIMITATION OF THE STUDY

This study does not cover all states in the Federal Republic of Nigeria and as such cannot represent overall views. It does however indicate reasonably how the doctors would react to a situation of emergency arising from a fall-out. Secondly, the ordinary people in the society who would normally constitute the bulk of the victims of a fall-out, have not been interviewed.

ANALYSIS OF RESPONSES

In this exercise, the responses are grouped and recorded with a view to giving the reader a chance to draw personal conclusions.

Doctors' Responses to Questions on Radiation Management (N = 32)

Subject questions	Responses (% to the nearest whole number)
Year in practice	1-10 (60%); 11-20 (20%); above 20 (20%)
Approximate number of patients treated.	500-10,000 (60%); above 10,000 (40%)
Specialised area of practice.	Surgery (20%); Medicine (25%); Obsterics and Gynaecology (12%); General Practice (32%); Pediatrics (11%).
Experience in the use of X-ray in Medicine.	Good - Excellent
Identified dangers of long exposure to radiation.	Cellular damage, irradiation, bone neurosis, Cancer, mutation of genes, congenital mal-formation, infertility.
A disease similar in presentation.	Leukaemia; Cancer
Knowledge of use and deployment of nuclear weapons.	i) No idea (40%) ii) Fair knowledge through reading (60%)
Have you handled any radiation case before? Response of patients if Yes	No. (80%); Yes (20%) Slow response (12%); Death (8%)
What would be your reaction in event of a fall-out?	i) No idea (40%) ii) Evacaution of inhabitants of affected area and treatment (25%) iii) Others (35%) - Serious concern. - Panic. - Sad. - I'll run for dear life if not directly affected.

Subject questions	Responses (% to the nearest whole Number)
Posibility of Nigeria being affected by a fall-out.	Most possible - (20%) Just possible - (60%) Fairly possible - (20%)
Level of Preparedness to handle cases.	None (0%)
Need for mass Education of the populace	Yes (100%) Urgency Level: Very Urgent - (25%) Just Urgent - (20%) Not so Urgent - (55%)
Personal views (selected few).	1. The risk of a fall-out is real but far greater if one's country develops nuclear energy. 2. There is the need for general education on radiation and radiation effects. 3. Call for a stop in the development of nuclear weapons. 4. Need for cooperation with anti-nuclear war groups in the world to reduce the risk of war. 5. People should be trained in the management of cases in this field of medicine rather than wait until it happens. 6. Nuclear energy though cheap to maintain (not to acquire) is still a risky venture to be undertaken by developing nations. Accidents in developed nations testify to this. Management of victims of radiation is still not easily accomplished and severely affected victims invariably never make it. Hence, for prevention of such accidents, we have to limit or even dismantle the various plants and weapons. Nuclear proliferation is definitely to be discouraged by all sane and peace loving peoples of the world.

DISCUSSION AND CONCLUSION

A high percentage of the doctors have not managed radiation cases and have only a fair knowledge (through reading) of presentation of cases resulting from nuclear fall-out. Individual reactions of the respondents in event of a fall-out show a disturbing "no idea" submission and a feeling of panic. While the respondents generally accept that there is a possibility of Nigeria being affected by a fall-out, there is no preparation towards handling affected patients. The need for mass education of the populace is registered and a call for reduction and dismantling of nuclear weapons re-emphasised.
I recommend that radiation science and resulting hazards should form a part of our contemporary issues in Science Education.

Consequently, science education programmes in institutions should involve these issues as a component of environmental science education programme.

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PRE-UNIVERSITY EDUCATIONAL SYSTEM IN NIGERIA

Nigeria operates a national educational structure commonly referred to as the 6-3-3-4 system.

The first 6 years	-	Primary Education, ages 6 - 12
The next 3 years	-	Junior Secondary School (JSS), ages 13 - 15
The following 3 years	-	Senior Secondary School (SSS), ages 16 - 18

The last 4 years are on the University programmes.

- Mode of Assessment:

Primary: Assessment is conventional within the programme. Each year is broken into three terms and examinations are conducted at the end of each term. Promotion examinations are at the end of the year's programme and are normally school examinations. Overall programme examination is at the end of the 6th year and is conducted externally. This is the certificate examination.

Secondary: (JSS and SSS).

Evaluation is by continuous assessment through course work, end of term examination and final programme examination all of which are used in computation and determination of final grades - subject by subject. The **weighting is** - Continuous Assessment (60%); end of programme examination (40%).

A BRIEF AUTOBIOGRAPHICAL NOTE

A holder of B.Sc. (1st Class Hons) Chemistry, London and Ph.D. (Ibadan); 21 years post qualification experience in teaching in tertiary institutions; Deputy Provost of the College of Education (1978-84); Acting Dean of the Faculty of Science (1984/85); Dean, Faculty of Education (1985 - 86).

Presently: Reader (Science/Education - Chemistry); Director Institute of Education and Head, Department of Curriculum and Instruction, University of Cross River State, Uyo, Nigeria.

Publications: Fifteen publications in the areas of natural products chemistry, organic synthesis and Science Education.

GENERAL STUDIES IN THE SOCIAL DIMENSION OF SCIENCE AND TECHNOLOGY

Martin E.D. Henry, B.Sc., Dip. Ed. (Jamaica)

Some measure of understanding of Science and Technology has become a necessary requirement for functional citizenship in all modern societies. Science has been the prime creator of contemporary industrial civilization, and the ordinary citizen living in a 'scientific' society will be confronted with numerous decisions which only a knowledge of Science can help him make intelligently. By a 'knowledge of science' we do not mean knowledge of the details of Biology, Chemistry, Physics and other scientific disciplines; rather we are referring to a general understanding of what science is, how it operates, how it developed and how it's findings have been and can be applied - in short, a grasp of the social dimensions of Science and Technology.

It must not be assumed that Science students will naturally acquire this understanding. The manner in which school science is generally taught - as facts, laws, theories and experiments, fragmented into compartmentalized disciplines, does not provide a suitable environment for the development of such an understanding. Non-Science students have even less opportunity of examining Science and Technology in their broadest, most general context.

The Pre-University (sixth form) General Studies Programme at Brown's Town Community College in Jamaica, has provided the author of this paper with an opportunity to introduce students to the"human side"of Natural Science, to provide a forum for them to develop the capacity to evaluate and choose on the basis of available scientific information.

A short course, "General Studies (Science) has been developed and taught to four successive groups of Pre-University (Advanced Level) students over the past four years. All the groups were a mixture of Arts, Social Sciences and Natural Sciences students. The organisation of the course, teaching strategies, methods of evaluation and an assessment of it's impact, are briefly summarised in this paper.

"COURSE DESCRIPTION"

This course very briefly surveys the nature and the growth of Natural Science, the impact of scientific ideas on man and his world, and it will also examine some of the disturbing moral and ethical issues raised by the application of scientific knowledge, and the place of Science in Jamaica.

"AIMS"

This course is designed to help students in providing meaningful answers to the following questions:

(1) What is Science? (2) What do Scientists do?
(3) How do Scientists do what they do?
(4) How has Science affected man and his world?

(5) How can Science affect man's future?
(6) What are the social responsibilities of the Scientist?
(7) Of what value is a knowledge of Scientific principles?
(8) What are some of the 'Big Ideas' of Modern Science?
(9) How did these ideas develop?
(10) What role is Science playing in the growth and devlopment of Jamaica?

IN ADDITION

Students should develop skills in:
(1) Collecting and using information.
(2) Organising information and presenting it orally or in writing.
(3) Analysing, Synthesing and Evaluating information for decision-making in areas related to Science.
(4) Collaborating with others.

"COURSE CONTENT"

Introduction & Overview

Discussion of the following questions:
(i) What is Science? (ii) What do Scientists do?
(iii) Of what value is a knowledge of Scientific principles?

The Nature of Science

(i) Basic postulates of Science
(ii) The Scientific Method
(iii) The Scientific Revolution
(iv) Major concepts ('Big Ideas') in Science
(v) The role of Accident and Imagination in the progress of Science

The Growth Of Scientific Ideas

A brief survey of the history of science through a biographical study of a selected group of major scientists.

The Impact of Science on Man and His World

(i) Technology (ii) The Industrial Revolution
(iii) Particular fields for consideration:
- Medicine, Agriculture, Materials, Communications, Warfare, The Environment, Art, Religion.

Morality, Values and Ethics in Science

(i) Discussions of crucial issues in Society raised by the practice of Science. e.g. Nuclear war, Life-Support systems, Genetic Engineering, Pollution, Machines displacing Human Labour.......
(ii) Debate on the control of Science and Technology.

Science in Jamaica

(i) Institutions of Science in Jamaica. Their contributions to the society.
(ii) Applications of Science in Jamaica

-imported technology
-indigenous technology

(iii) A Science and Technology policy for Jamaica. Plans for the future.
(iv) The role of Science Education in Development Strategies for Jamaica.

"TEACHING STRATEGIES"

With limited time available, much of the work was done outside of classes in independent or group researches. Class sessions were mainly used to discuss, debate, clarify, amplify and integrate into a cohesive pattern, data which were collected. Students were required to present their findings and to face challenges from their peers. Mini-lectures of 10 - 15 minutes duration were used to present some material and to spark discussions or to define the scope of assignments. Research efforts not only saved time, but provided vehicles for acheiving the additional objectives of the course.

Teaching resources were largely limited to books, journals and local newspapers available in the College library and the public library. There was no access to audiovisual resources, nor opportunities for field visits though both teacher and students recognise the potential value of these.

"EVALUATION OF THE COURSE"

General Studies (Science) has been assessed on two bases:

1. The performance of the students on terminal assigments (a major research essay and a scrapbook of items - on a scientific theme relative to the objectives of the course); and
2. The response of students to the content and methods of the course (questionnaire given at the end of the course)

GENERAL STUDIES (SCIENCE) COURSE EVALUATION QUESTIONNAIRE

1. Were you interested in the course? Why?
2. How much work did you put into the course?
3. How well could you follow the material presented?
4. If you had difficulty following, say why this was so.
5. Which part of the course did you like most? Why?
6. Which part of the course did you like least? Why?
7. Was the course in any way relevant to your needs? If yes, how?
8. Would you recommend that this course be taught to the students who come after you? Why?
9. Suggest ways in which the course could be improved.
10. Comment on the way the tutor conducted the classes and related to the students.

Continuous dialogical interaction in classes yeilded valuable non-quantitative data on both performance and response. Every effort, including informal seating arrangements, was made to encourage students to talk, to question and to challenge.

Results

In the four classes taught so far, a total of 93 students have participated in this course.

TABLE I : Class Performance on Terminal Assignments

PERFORMANCE DATA	CLASS I	CLASS II	CLASS III	CLASS IV	COMBINED CLASSES
Mean Essay Score (%)	56.9	59.5	60.5	59.6	59.1
Mean Scrapbook Score(%)	63.1	58.0	70.5	58.9	62.6
Mean Total Score (%) (Essay &) (Scrapbook)	59.6	58.8	65.5	59.3	62.0
Standard Deviation For Total Scores	20.7	19.8	19.3	15.6	18.9
% of Total Scores ≥ Minimum Satisfactory Score of 50%	72.7	76.5	80.0	80.0	79.8
% of Scores ≥ Mean Score	63.6	41.1	50.0	50.0	51.2

Mean class scores have been in every case considerably greater than the minimum satisfactory score of 50% and score distribution has been biased toward the higher end. An average of 51.2% of the students achieved total scores greater than the combined class means.

Standard deviation values indicate a rather broad distribution of scores. It seems that the most important difference between students gaining high scores and those getting low marks is the quantity and quality of research and organisational work undertaken. Classes were fairly homogenous in intellectual ability as judged by entry qualifications for the sixth form. There was no significant difference in the performance of the Arts and Science specialists in the classes as Table II shows.

TABLE II : Relative Performance of Arts and Science Students
(From Total Scores)

PERFORMANCE DATA	CLASS I	CLASS II	CLASS III	CLASS IV	COMBINED CLASSES
Mean Score Arts (%)	60.1	57.4	68.3	58.5	61.8
Mean Score Science (%)	59.1	60.2	62.7	59.9	60.5
Difference in Mean Scores	1.0	0.8	4.6	1.4	1.3

In so far as the assignments have reflected the objectives of the course, the classes have shown modest achievement of those objectives.

Questionnaire responses (which because of limitations of space cannot be presented in detail) indicate that most students were interested in the course and found it relevant and useful. Every student recommended that the course be taught to the group coming after him.

If the short introductory Section A of the course was omitted, then the best liked sections and activities of the course rank :

D > E > DISCUSSIONS > F > C > B > RESEARCH.

DISCUSSION

The very great popularity of Section D - 'The Impact of Science' and Section E - 'Morality, Ethics and Values' justifies the rationale for offering General Studies (Science). The level at which it was taught was neither unmanageably difficult nor too easy to be challenging.

Time and resource constraints have imposed some severe restrictions on what could be accomplished by this course, but the results are nontheless encouraging.

General Studies (Science) was designed for a small, highly specific group which is at a fairly advanced stage in the educational system of Jamaica. A course of this nature could be made more generally useful if modified to fit into a General Education Curriculum for less advanced students.

There is a pressing need for courses of this type in the Educational Systems of Developnig Countries where the development pathway is largely percieved as a technico - scientific one. Citizens will need a basic understanding of Science and Technology to make critical choices about personal and societal problems.

> "General Studies (Science) is the only way in this institution that the importance of Science and how it affects people's lives can be presented to stuents" (a response to Question 8 of the course evaluation questionnaire).

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AUTOBIOGRAPHICAL NOTE

Bachelor of Science Degree in Zoology and Chemistry.
University of the West Indies (Mona Campus) 1981.

Diploma in Education in the Teaching of Science,
University of the West Indies (Mona Campus) 1984

I have been employed at Brown's Town Community College, St. Ann, Ja. as teacher of Biology, Chemistry and General Studies (Science) since 1981. I obtained study leave in 1983/84 to pursue the Diploma in Education course. I also serve as Dean of Academic Affairs (since 1984) and Head of the Science Department (since 1982). I have recently been promoted to Senior Lecturer (1986).

THE EDUCATIONAL SYSTEM IN JAMAICA

The educational system in Jamaica incorporates many elements of the British System from which it was derived in colonial times. It is presently a terribly complex and unweildly system, but efforts are under way to simplify it and to raise its efficiency.

LEVEL 1 : Early Childhood Education (Basic School)
Age : 3 - 6 years. Less than 10% of 3 - 6 year olds attend. Most schools are privately run but may be subsidised by government.

LEVEL 2 : Primary Education (Two types of Schools)
Type I - Age; 6 - 12 years, Grades 1 - 6; 43 % of students.

Type II - Age: 6 - 15 years, Grades 1 - 9; 57 % of students.
Last three grades offer an attenuated secondary curriculum.
Universal Free Primary Education.

LEVEL 3 : Secondary Education (Four main types of secondary)
(schools)
Type I - Grammar High School; Academic Curriculum.
Age : 12 - 18 years. Entry by highly competitive examination taken at Grade 6.
30 % of secondary students.
Grades 7 - 13 (Last two grades are Pre - University with relatively few students)

Type II - New Junior Secondary School. Vocational Curriculum.
Age : 12 - 17 years.
Automatic entry from Type I primary school.
60 % of secondary students.
Grades 7 - 11.

Type III - Technical High Schools. Academic - Vocational Curriculum.
Age : 15 - 18 years.
Entry by very competitive examination taken at Grade 8 in Type II primary or New Secondary.
4 % of secondary students.
Grades 9 - 12.

Type IV - Comprehensive High School. Academic - Vocational Curriculum.
Experimental combination of Grammar High School and New Secondary School.
Age : 12 - 17 years.
6 % of secondary students.
Grades 7 - 11.

Secondary Education is Universally Free but highly variable in quality.

LEVEL 4 : Tertiary Education (University of the West Indies)
English - speaking caribbean regional university.
3 campuses.
Entry by British Advanced Level Examination, taken in Grammar High School Grade 13 or Community College.
A typical university, Degrees granted.
35 % of tertiary students.

Tertiary Education - College of Arts, Science & Technology (CAST)
Advanced vocational training.
Entry by secondary school leaving examinations taken at Grade 11. Diplomas & Certificates granted.
23 % of tertiary students.

Tertiary Education - Community Colleges.
(There are 4 of these)
Combination Sixth Form College and Vocational Training Institution.
External Examinations taken, Certificate granted.
15 % of tertiary students.

* Course taught to Pre-University (sixth form) students in one of these.

VARIOUS INSTITUTIONS - Private and State run for training Nurses, Teachers, Agricultural Personnel, Business Personnel, etc.,
Diplomas and Certificates granted.
27 % of tertiary students.

Approximately 2 % of the population attain tertiary education.
No tuition fees between 1973 and 1986. Fees now reintroduced for U.W.I. and C.A.S.T.

SCIENCE AND TECHNOLOGY EDUCATION AND THE CONCEPT OF QUALITY OF LIFE

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At present, "improvement of the quality of life" appears as one of the objectives of teaching in the secondary school (LEWIS, 1981).

For some, the quality of life is an absolutely valid factor for the whole human species. This situation, the result of a process of massification, levels expectations, stimulates consumption, and imposes the same values on different communities. However, it is necessary to take into account that the quality of life is defined by the pretensions which prevail at a certain historical moment in each community and which imply, at times, in very pronounced differences.

Parallel to the biological evolutive process, the quality of life is a function of paradoxically complementary attitudes: the **maintenance** of values, cultural standards, traditions and technologies, and the **innovation** that brings about ruptures in the routine, renews customs, creates new products and develops technologies. Thus, improvement in the quality of life depends on antagonic conditions. One condition is respect for tradition and for the practices consecrated by a certain community as part of its culture and beliefs. The other condition, which complements the first, is the possibility of constant renewal by means of the introduction of new techniques, new values, new forms of subsistence, and new forms of seeing and facing the same subjects.

The incessant attempt to improve the quality of life is one of the peculiarities of the human species, creating differences that make this species ever-changing and multi-faceted.

A biological characteristic upon which survival of all species depends is food, which maintains the same standard throughout time. The human species is the only species that constantly looks for new foods, depending on progress in the identification of edible organisms and on new methods of preparing and preserving food. New types of food and drink are constantly invented, multiplying the possibilities and the repertoire for meals, determining cultural standards and differentiating religious, cultural and ethnic groups. But it is remarkable that, at the same time that man can always count on new alternatives for his diet, some human groups create taboos that forbid them to eat certain types of food, even in the face of extreme danger.

Clothing is also an example of the biological process of adaptation to the climate, and one which led to the search for new forms of protection and of beauty, using different materials and new forms, defining national groups, social classes, and aesthetic standards which come to identify certain human groups. In this process one identifies both those societies considered primitive, that produce clothing with the beauty of the feather art of the indians, and those societies considered advanced, that produce the new fibers, weaving patterns, designs and modelling which constitute fashion.

As far as habitation goes, the human species is not content with one single standard as are other species. Changes in the architectonic structure of the buildings where man lives have characterized regions, societies and historical periods, thus surpassing the biological sphere to define, instead, a cultural territory.

Within these processes, the diversification of the instruments used in the search of new ways of satisfying the desire for change and improvement, as well as the maintenance of standards considered acceptable and desirable for the improvement of the quality of life, played important roles. Quality of life depends, therefore, directly on man's relationship with nature, and with the members of the community to which he belongs.

Quality of life is not restricted to the fulfilment of biological necessities, but implies in the fulfilment of individual and group aspirations. Nowadays one must include among these aspirations not only food, shelter and clothing, which were already mentioned, but also education, health, working conditions, availability of leisure, etc.

Traditionally, the analysis of this type of problem was left to the teachers of Human Sciences, but in the present phase of development of the teaching of Sciences, educators all over the world point out the necessity of taking into consideration the social implications of scientific development, as well as nature itself, and technology, its way of operating and its consequences on the quality of life, in courses of the scientific disciplines.

Many countries are revising Science curricula for very diverse reasons: political liberation and affirmation of the cultural identity of nations and peoples; expansion of educational systems and the quest for the democratization of education; preoccupation with "international economic competitions, in the center of which is each nation's struggle to dominate the technological mutation with which all are faced" (CHEVENEMENT, 1984).

This revision has led to programs which point out and emphasize Science/Technology, and quality of life/economic development relationships, among others. Consequently, Science teachers have new attributions, and are forced to face situations for which they are not always prepared. They have difficulty in handling problems with political, economic or social connotations since university courses, following the traditional line of alienated and asseptic Science curricula, are mainly concerned with the transmission of sparse and often disjointed factual content.

Teaching and Learning Methods

There are several aspects that touch on problems related to the quality of life, and which must be brought to attention of students of Science courses.

Multi-culturality: It is imperative that pluralist societies recognize and accept their complex cultural compositions. In the classroom, students must be helped to understand and appreciate the contributions of ethnic and social groups, and of communities with values, traditions, and diversified knowledge. The multi-culturality analysis process must be carried out in such a way as to avoid types of ethnocentrism which unterlie the actual nomenclature used in the classroom. Words such as "primitive" as opposed to "modern", and "developed" as opposed to "under developed", may give students the impression of inferiority which it is so important to avoid when our aim is to valorize social pluralism. The contribution of different cultures in the development of humanity, the explanation of ethnic differences, must be consistently based on information if they are to be accepted naturally and rationally by the students.

The teaching of Biology can play an important role in this process. Diets of different regions can be analyzed and related to health problems, growth processes, eating habits and disease. Nutrition, vitamin deficiencies, the incidence of diabetes and dental problems can be related the multi-cultural differences should be made from the international perspective, or, in countries such as Brazil where there are great regional differences, from the domestic perspective in which regional differences are analyzed and discussed by the students.

Science/Technology/Society Relationships: Starting with the first living beings, modern Science programs include analyses of the scientific process and of its relationship with technology and with the society.

The use of materials and the necessity of finding ways to overcome deficiencies can serve as a starting point for analysis of the relationships that exist between Science, Technology and Society. The distribution of materials is related to scientific development, with political and economic consequences. The production of remedies, food, work implements, varied products and the manufacture of handicrafts depend on the availability of raw material and on technological capacity, but is closely connected to marketing processes. Accessability depends not only on the desire for comfort, but also on ship and the distribution of power related to processes of hostility, justice and injustice, also create conflicts which must be considered by Science at some point in their courses.

It is neither possible nor advisable to avoid treatment of the analysis of problems involved in Science/Society relationships if we wish to form conscientious citizens, capable of acting in a democratic society.

Science/Technology and Environment Preservation/Restoration Relationships: Students must understand the impact of scientific and technological development on the environment, and although it is not advisable for them to assume an alienated position through ignorance of the problem, it is equally unadvisable for them to take an emotional stand unbased on knowledge and thereby consider science as the major cause of attacks on environment.

Environmental preservation, as an essential ingredient of good life quality, must be amply discussed so as to relate the problem to aspects such as urbanization/life in a rural environment, and working conditions/leisure.

Certain procedures on the part of teachers may help to achieve the objectives mentioned, such as the introduction of new contents and new teaching methodologies.

Relating scientific problems to human aspects: It is impossible to teach Sciences without analyzing the causes of scientific discoveries and their consequences on the human species. Historical aspects and geographical differences should be introduced in such a way as to situate science within a broader context.

Analysis of ethical problems should be included in such a ay as to emphasize the analysis of controversies and the limitations of solutions. For example, in one of the projects developed in the Science Teaching Center of Sao Paulo (CECISP), one of the activities developed is the simulation of a meeting of scientists in which the validity of putting into practice a method to make rain with no knowledge of the side effects it may produce is discussed. The personages assume roles which represent, basically, two levels of decision making: that of the scientists in terms of individual or collective responsability, and that of countries, developed and underdeveloped, in terms of interest in environmental preservation, of better life quality, and of research financing. Actually, the activity brings the student to analyze, as well, the relationship between the scientist and society in deciding upon priorities for investigation and problems involving the autonomy of the scientists.

Focusing on concrete current problems: Youth should be led to face current problems in such a way as to make clear their own positions in relation to these problems in a well-informed and well-fundamented manner. For example, in Brazil, analysis of the use of alcohol as fuel and reasons for development of the appropriate technology, related to the energy crisis and its consequences, make the study of the "Prô-Álcool" program an exemplary case study which is very useful from the point of view of analysis of the social implications of science and of technology.

Analyzing events on the regional, national and world wide level: In many cases there are conflicting interests and several conflicting view points on one subject. Students must be led to take into consideration all the various aspects of the subject. Responsibility for environmental preservation is not restricted to one region, to one country. An example of a subject for duscission in this category could be acid rain and the advisability of building nuclear power plants in Brazil, and the advantages and potential dangers involved.

Analyzing Science/Technology/Develkopment Relationships: The conception of development/underdevelopment and of its relationship with the scientific and industrial capacity of each country may allow students to analyze the subject in such a way as to appropriately valorize the role of science and of technology. This will not be possible without relating the problem to neo-colonialism. Brazil's dependence on raw materials and patents for production, and the role of bio-technology are examples of topics that will help the teacher and the student to discuss the subject.

The Future: Although Science courses must focus on current problems, they must not fail to consider, from a prospective viewpoint, how science and technology should develop so as to better ensure that the world be a place of peace and justice in which the quality of life really fulfills the aspirations of each community.

Methods: It is obvious that the topics and subjects suggested cannot be handled adequately in class by means of expositive methods. Discussion and teacher-student interaction are essential if youths are to acquire information and analyze values, conceptions and aspirations in such a way as to make clear exactly what they consider a desirable quality of life, levelled off at a plateau on which there could be a multiplicity of possibilities for the fulfilment of all.

The didactic modalities to which teachers can resort are varied: **simulations** are good for the discussion of processes of conflict, but may involve the danger of developing in the young the capacity for argumentation unbased on conviction. It is essential, at some point in the course, that each person make his or her opinions, as well as the reasons for these opinions, very clear; **case studies** are also very good for the study of society/science relationships. Analysis of problems such as the anti-pollution program of the city of Cubatao, Sao Paulo, Brazil, based on newspaper and magazine cuttings and taking into consideration the opinions of scientists, industrialists, city inhabitants, workers, politicians and of environmentalists on the subject, stimulates very fruitful discussion and reflection; **visits to factories, business firms and farms** are useful not only for the students to observe scientific processes applied on a large scale, but also to ensure that they will not neglect the human element and working conditions. The Science teacher's repertoire is vast, but it implies in a basic change of position if activities are to achieve success.

The main objective of the inclusion of subjects that lead the student to analyze elements that interfere in the quality of life is to synthesize his opinions, leading him to build up his own concept of his own individual aspirations, and of the aspirations of the community in which he lives. This process will be the beginning of more profound studies and actions that can lead to actual improvement of the aspiration level.

To bring this about, broadening of the objectives of regular school Science courses is not sufficient. Teacher training schools must broaden their objectives as well. The development of educational resources is also essential to give professionals an incentive to evaluate the importance of the problem, and to hepl them recognize that they need support to carry these objectives into their classrooms and to develop new ideas and proposals.

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The **Brazilian educational system** is composed by - primary school - 5 years (7 age 11),middle school - 4 years (11 age 14), high school - 3 years (15 age 17).

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ARMS CONTROL ISSUES IN SCIENCE AND TECHNOLOGY EDUCATION

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President Dwight D. Eisenhower delivered his farewell address to the American people more than a quarter of a century ago, but his explanation of the development of the "military-industrial complex" and the special problems that such a configuration of powerful organizations pose for democratic societies is still accurate. Fewer persons remember his other warning that "public policy could itself become the captive of a scientific and technological elite."

Most discussions of the relationships linking science and technology education to arms control and national security focus on the need for technological advance. The argument is straightforward, if one-dimensional: if education programs lag, nations will not produce enough of the highly trained engineers, scientists and technicians needed to support the technological innovations that are the forces behind the development of new weapons. The effects are remarkably similar, east and west. In the U.S., about seventy percent of the federal budget for science and engineering research and development is allocated for defense-related R&D (1). There is little reason to believe that the Soviet Union invests less. This paper suggests approaches for science and technology educators who want to ensure that public policy is shaped with the vigorous participation of educated citizens in order to avoid the danger suggested by President Eisenhower.

Science, Technology and Arms Control

Scientific and technological literacy is essential for an informed discussion of arms control issues such as those listed below.

- The strategic defense initiative.
- Environmental effects of nuclear weapons.
- The decision to produce binary nerve gases.
- The debate over the deployment of antisatellite

weapons.

- Nuclear weapons testing.
- Biological weapons and genetic engineering.

How effective are secondary education programs, introductory college courses for non-science majors and programs for science and engineering degree candidates in providing the background needed to deal with these issues?

Precollege Science and Technology Programs in the U.S.

The United States continues to do a generally inadequate job of teaching basic science and technology at the precollege level. Pockets of excellence exist, but relatively few states have responded adequately to the problems pointed out by highly critical studies (2). Resource allocations have increased modestly but most systems do not support teaching conditions that foster excellence. The revolution that is called for by the studies has not taken place.

Few courses include any study of public policy issues with science and technology content such as those related to international security and arms control. Nor are these issues likely to be discussed in detail in social science courses. Since most students do not complete college, most will never have any formal opportunity to gain an understanding of the science and technology needed to participate in an informed national security policy and arms control debate (3,4).

Barriers to the Discussion of Arms Control Issues

Despite the existence of pilot projects as "Science Through Science, Technology and Society" developed at Pennsylvania State University under the direction of Rustum Roy, relatively few teachers have access to the necessary curriculum resource materials or to sources of training (5). Few state science syllabi devote significant attention to science, technology and society issues. With insufficient time to teach an already overcrowded syllabus, it is unrealistic to think that most teachers will be willing to devote time to the study of science, technology and society issues (6).

Higher Education: Adequate for Public Policy?

Undergraduate science and technology education for non-science majors in the United States is uneven in quality (7, 8). Observations and reports suggest that many of our undergraduate science courses for non-scientists are not adequate for the analysis of public policy issues with science and technology components such as those involving arms control and international security.

Many faculty claim that non-scientists should be more familiar with the impact of science and technology on public policy, but most ignore the needs of science and engineering majors, arguing that time should not be taken from traditional study. As a result few of these students have systematic opportunities to participate in thoughtful discussions of the way in which science and technology policy is developed. It is possible to spend nine years as a physics student and never participate in a discussion of a public policy issue in a regular university science or engineering course. Arms control and international security issues are ignored (9). Such insularity often results in undergraduate and graduate educations which are exceptionally narrow. Some students emerge with arrogant technocratic attitudes that take little account of the social functions of science and technology, to say nothing of arms control issues.

Many faculty avoid relating science and technology to national security and arms control because they are reluctant to mix their disciplines with what they regard as "politics." These views are seen in the vigorous exchange of letters in journals such as Physics Today, Chemical and Engineering News and Science. Policy issues related to science and national security are regarded as particularly sensitive by many who fear the improper use of the classroom to advance ideological positions.

Science and technology organizations make significant efforts in many forums to influence policy making and resource allocation. National security is routinely invoked as part of the rationale for the continued large scale support for research and development. Arguments seeking support for science to increase the quality of public policy debates are advanced much less often. Yet without such policy debates, we run the risk, as Eisenhower put it, of yielding the arms control debate to elites. Would the U.S. and the Soviet Union possess such large nuclear arsenals had of our strategic nuclear doctrine been more clearly perceived, proclaimed and fully debated? Defense spending might be reduced if more persons understood their impact on the economic health of nations (10). Without the opportunity to acquire the broad perspective that can only be developed over a period of many years, public understanding of these issues will remain narrow and uninformed.

Progress

Colleges and universities in the United States are responding to the need to broaden the public discussion of policy issues by creating special courses exploring the relationship linking science, technology and society. A growing number of these courses examine issues related to international security and arms control (11). Dietrich Schroeer's physics course at the University of North Carolina, has been offered for many years. Others, stimulated by the sharp emergence of technological and scientific policy issues in the international security arena, have been developed more recently by scientists and engineers who regard these topics as important.

Organizations such as the Federation of American Scientists, The American Association for the Advancement of Science, The American Association of Physics Teachers, the American Physical Society and the National Science Teachers Association have developed educational materials and sponsored short courses and symposia on some of the most important issues in international security. Two introductory physics texts organized around the application of physics to national security issues have already been published (12, 13). Science and technology education organizations in the United States are beginning to deal with the problem of creating a more informed body of public opinion that can be directed to public policy issues related to international security, but much more needs to be done.

There are other, more incremental, approaches. Arms control issues can be used by teachers to illustrate scientific and technical principles. For example, discussions of the propagation of seismic waves through the earth can be illustrated by examining the current debate in the U.S. over the verifiability of a comprehensive nuclear test ban. Classes studying the transmission of radio waves can explore the way in which the information capacity of radio signals is related to frequency by examining the low frequency system designed for communication with submerged submarines.

The concepts of precision and accuracy can be illustrated with examples drawn from discussions of circular errors and hard target kill probabilities of strategic nuclear missiles. The physics of satellite motion can be illustrated in the framework provided by the U.S. Strategic Defense Initiative. The effects of nerve gas can be explained in biology classes studying synaptic junctions. Anyone familiar with these issues could extend this list of topics.

Leaders in science and engineering programs must encourage the development of elective courses that explore science, technology and public policy issues developed by faculty representing appropriate disciplines. It would be a major advance if every student had at least one opportunity to participate in such a course.

The State University of New York at Stony Brook offers two courses exploring arms control issues and their relationship to the scientific and technological enterprise. "Nuclear Proliferation: Technology and Politics" begins with a study of the physical principles of nuclear fission, basic engineering design of nuclear reactors and an examination of the nuclear fuel cycle. Students examine the Nonproliferation Treaty and the political incentives and disincentives for proliferation from the point of view of both developed and developing nations. We make it possible for students to visit nuclear laboratories, nearby international organizations and U.S. government offices concerned with nuclear proliferation.

"Science, Technology and Arms Control" examines the way in which science and technology contribute to weapons development and to international control efforts. Students become familiar with the basic technologies involved in the development and production of modern weapons systems. They study arms control agreements and current negotiations between the United States and the Soviet Union (14).

Both courses require students to read widely and acquire broad familiarity with the literature published by organizations such as the International Institute for Strategic Studies, Stockholm International Peace Research Institute and The United Nations. Students are encouraged to read The New York Times, Wall Street Journal, Washington Post Weekly and the English language edition of Pravda.

A few of our students have gone on to graduate study in arms control and national security policy at schools such as Columbia University and the Massachusetts Institute of Technology. Many students who will pursue other careers say that the course has opened up new vistas. As one of them put it, "I now turn to articles on arms control issues first when I pick up the New York Times. Before, I never read them at all."

The Future

A broader international perspective is more likely to be achieved in all societies if teachers of science and technology include discussions of arms control issues in teaching programs. Without a more informed citizenry and a greater number of scientific and technical professionals who understand the relationships linking their fields to international security affairs, powerful elites will dominate the debates and exert unwarranted influence on national security policy decisions, just as Eisenhower foresaw.

We can enlist the cooperation of our colleagues in the social sciences to help us create informed dialogues enabling our students to participate more fully and thus be better prepared to influence policy decisions. Much can be done with modest investments of resources. If we heed Eisenhower's other warning, we must attempt to create a more informed citizenry and a new generation of scientists and engineers who possess a broader understanding of the international security implications of their work. Institutions of higher education, professional scientific and engineering societies and secondary schools of all nations should cooperate to share information and exchange ideas about ways in which these programs can be expanded and made more effective..

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U.S. children between the ages of 6 and 18 are entitled to twelve years of precollege education in systems supervised by the individual States. About eighty percent graduate from high school. Perhaps half go on to some form of postsecondary education. About sixteen percent of the adult population will eventually complete four or more years of higher education. This paper deals with the secondary schools and higher education.

Lester G. Paldy directs the Center for Science, Mathematics and Technology Education at the State University of New York at Stony Brook and is a faculty member in the Department of Technology and Society. He has served in Washington on the staff of the National Science Foundation and is a Fellow of AAAS. His current research interest is in remote sensing and arms control.

THE IDENTIFICATION OF CONTENT SUITABLE FOR A SCIENCE, TECHNOLOGY, AND SOCIETY CURRICULUM IN A DEVELOPING COUNTRY

William E. Searles & Zurina Hayati Meah (Canada)

During the past four decades considerable advances in science and technology have resulted in important contributions to the quality of life in developed countries but basic problems associated with human suffering of the majority of persons in the third world still remain. It is therefore important to determine how to utilize recent developments in science and technology to ensure that meaningful benefits evolve in developing countries. Education has long been recognized as a major influence in such an evolution being viewed as "a productive investment and an essential factor in the economic, social, and technological development of a developing country" (Morris, 1983, p.52). One approach in education to help overcome such concerns is to modify the general science core curriculum so that the majority of high school students become aware of how the science they learn is related to the environment in which they live. This type of curriculum would incorporate and emphasize the interrelationships of science, technology and society, to produce educated laymen regardless of the diverse nature of their future careers.

A review of the literature revealed the importance of an STS curriculum to the needs of a great number of students in industrialized and developing countries (Bybee, 1980; Eikelhof, 1982; Hall, 1983; Hurd, 1975; Lewis, 1978; Marland, 1981; McConnell, 1982). Many STS curricula have been implemented world-wide but few have attempted to incorporate STS issues into the existing science curricula. The approach of infusing STS issues into an existing science curriculum was specifically chosen because it appeared to be the most viable one under the prevailing socio-economic conditions in a developing country.

The purpose of this study was to identify technology and societal items that could be related to and/or included in a general science core curriculum. In particular, it was hoped that knowledge of these items would help to reorientate the Malaysian Form IV and V General Science curriculum towards an emphasis on the interactions between Science, Technology, and Society. The result of such an orientation would enable a great majority of the non-science students taking the course to become more aware and to appreciate the relationships between science and technology, and their impact upon the individual and society.

The Sample

a) Selection of the Region. The State of Penang was chosen for the purpose of this study because it has: a history of strong scholastic achievement; a greater heterogenous school distribution within a multi-cultural region; two distinct regions, one urban and highly industrialized, the other rural, consisting of agricultural and fishing communities.

b) Selection of Teachers. One hundred and thirty teachers were randomly selected from a population of science educators teaching the Form IV and V General science core curriculum in Penang. Sixty-five of these teachers came from the urban area, the remainder from rural areas.

Instrumentation

The Penang Science, Technology and Society Topic Questionnaire (PSTSTQ) is an instrument designed to assess teachers' attitudes towards STS issues and consists of two main sections. Section one elicits information pertaining to the teachers' professional background whilst section two seeks the teachers' evaluation of STS topics within the areas of Biology, Chemistry, and Physics found in the Malaysian General Science curriculum. This curriculum was chosen because it would be the last science course undertaken by the majority of non-science students as well as those students who would be continuing their studies in science. Textbooks, journals, and other library resources were examined to construct a list of STS topics related to the general science curriculum and were based on the following guidelines. The topic must:

1. Be related to science and/or scientists.
2. Show the interrelationship between science and technology, technology and society, or science, technology, and society.
3. Be relevant to Penang's environment.
4. Be a science, technology, and societal issue.

Twenty experienced Kenyan teachers, seven graduate students, and four professors of McGill University aided in the evaluation of the final questionnaire which contained 151 STS items for Biology, 107 for Chemistry, and 43 for Physics. The questionnaire was then administered to 130 form IV and V general science teachers in the State of Penang who evaluated the STS items with the aid of a Likert scale.

Treatment

The data obtained were then analyzed to: determine the percentage response for each item using frequency counts, calculate the mean score for each item, and rank order the STS items. A chi-square test was then performed on each of the top and bottom 25% of the ranked items in Biology, Chemistry, and Physics.

Results and Discussion

From an analysis of the data it was found that 90.6% of the respondents in the rural area taught in co-educational schools whereas only 37.9% taught in the same type of school in the urban area. The data also indicated that 65.5% of the respondents in the rural area held B.Sc. degrees compared with 41.1% in the urban area. The vast majority in both areas possessed teaching certification and felt there was a need to teach STS topics in the general science core curriculum.

Items in the area of Biology like 38, 3, 6, 31, 39, and 61, are related to health and received high ratings with number 38: "The necessity of having a balanced diet to maintain healthy growth", receiving the highest rating of 3.60. This indicated that the respondents placed a great emphasis on nutrition and the need for students to understand this fact. Other items under Biology 133, 14, 44, 134, and 16, are related to the natural environment and were also given high ratings with number 133: "Air pollution and its effects on plants and animals", being rated the highest in this category with 3.42. In general, the respondents felt strongly about those items concerned with the pollution of the environment. Of those Biology topics related to food production numbers 43, 99, and 100 received high ratings. Number 43: "The importance of government control in the use of pesticides, insecticides, and herbicides on agricultural products", was rated highest at 3.40 suggesting that teachers are most concerned about the use of dangerous chemicals in the environment.
Items in the area of Chemistry like 58, 59, and 61, are concerned with energy. Item 58: "The use of solar energy for heating purposes" received a rating of 3.36 indicating a need to emphasize the importance of energy in the curriculum. A number of STS topics like 8, 66, 21, 50, and 36 were grouped under health in Chemistry, and in general received high ratings. Number 8: "The possible effects of colouring agents, which may have carcinogenic properties in food and the appeal of such food to the public" received a score of 3.20 which supported the teachers' concern for this area seen previously in Biology. Chemistry items 75, 69, 2, and 3, are related to the natural environment and within this area, number 75: "The uses of rubber and its value to the Malaysian society", was rated the highest at 3.27. Ratings given to items 69 (3.17), 2 (3.16), and 3 (3.07) illustrate that the science teachers are concerned

about pollution and see the need to help their students to recognize and understand this danger to their environment. In the area of Physics items were grouped under the themes of electricity, energy, and optics-consumer. Items 7, 11, and 12 were concerned with electricity and were rated highly with number 7: "The increasing use of the three-pronged electric plug for household appliances, e.g., washing machine, to give a ground wire and prevent electric shocks" obtaining a rating of 3.47. All three of the items were concerned with electrical hazards and the need to emphasize danger, or need for safety precautions were highly regarded by the science teachers. Two items, number 15, and 28, of the energy group stressed the importance of generators, and were given ratings of 3.19 and 3.22 respectively. Items 1, and 3, both dealt with the value of optical instruments to aid society which the teachers rated as important, (3.19) and (3.28) for the students to appreciate. In a similar manner, the items receiving low ratings, in the bottom 25% for Biology, Chemistry, and Physics, were examined to determine the reason they were not deemed as a suitable topic for an STS core curriculum.

Recommendations

It was suggested from the results of this study that:

1. The list of STS topics identified in the study should be considered by the curriculum development centre, Kuala Lampur, Malaysia, for inclusion in the general science core curriculum, or as a base for a STS curriculum.

2. If incorporated into the present or future curriculums, plans should be made to implement in-service courses for teachers responsible for teaching the course.

3. The STS topics resulting from this study should be re-evaluated and revised periodically.

4. Additional studies should be undertaken involving students, administrators, and representatives of the community.

5. Terminal examination should be changed to accommodate the aims and objectives of the curriculum.

6. Further studies should be undertaken to determine the specific needs of Rural versus Urban needs in an STS curriculum.

TABLE 1

RESPONSES OF SCIENCE TEACHERS TO STS ITEMS IN BIOLOGY, CHEMISTRY AND PHYSICS

Item Number	STS Biology Items	Mean
38	The necessity of having a balanced diet to maintain healthy growth.	3.60
3	The possible health effects of air pollution in an industrial area.	3.49
133	Air pollution and its effect on plants and animals.	3.42
14	The effects of pesticide and industrial waste contamination on marine life (plants and animals).	3.42
6	The potential increase of lung infections by the greater consumption of alcohol and tobacco.	3.41
43	The importance of government control on the use of pesticides, insecticides and herbicides on agricultural products.	3.40
44	The problems created by increasing world population.	3.38
31	The possible effects of drugs on the sensory perception of individuals.	3.37
134	The pollution of water supplies by insecticides, herbicides and fungicides.	3.34
61	The debate about breast versus bottle feeding and their relation to healthy babies.	3.26
99	The idea of hybridization of plants and animals to produce larger quantities of commodities at lower economic costs.	3.26

Item Number	STS Chemistry Items	Mean
58	Use of solar energy for heating purposes.	3.36
75	Uses of rubber and its value to the Malaysian society.	3.27
59	The storage of solar energy, produced on sunny days for use at night, would make it an important substitute for fossil fuels.	3.27
8	The possible use of colouring agents which may have carcinogenic properties in food, and the appeal of such food to the public.	3.20

Item Number	STS Chemistry Items Contd.	Mean
61	The improvement of quality of food substances and their possible supply of a greater source of energy.	3.19
69	The possible effects of oil slicks in oceans and leakage from oil wells drilled in shallow seas on Malaysian marine life.	3.17
2	The increasing conversion of natural resources to consumer goods and the treatment of waste materials to prevent pollution.	3.16
66	The role of sugar in the diet.	3.13
21	Canned food spoilage and its effects in a society which places little emphasis on expiry dates of consumer goods.	3.13
50	The long term effects of a nuclear bomb blast on a population.	3.13
36	The effect of nuclear reactions on a population.	3.09

Item Number	STS Physics Items	Mean
7	The increasing use of three-pronged plugs for electrical appliances, e.g. washing machine, to give ground wire to prevent electric shocks.	3.47
12	The awareness of the danger of using electrical appliances in the bathroom, particularly within reach of the sink.	3.36
11	The tendency of the public to use too many electrical appliances in the home which creates an overloaded circuit, and the hazard it causes to houses.	3.31
3	The contribution of optical instruments - cameras, projectors, microscopes, spectrometers - to a society.	3.28
28	The importance of generators for the conversion of mechanical energy to electrical energy to be used by commercial and household consumption.	3.22
34	The understanding of the pulley system and its ability to help man in his work.	3.20

In summation, a number of conclusions were made concerned with biographical details, instructional strategies, themes for STS items, conventional (discipline oriented) and unconventional (genetic engineering and bioethics, values) topics. A general conclusion was that this is a useful method for identifying STS content suitable for inclusion in a general science core curriculum. That science teachers holding a B.Sc. degree and teacher certification are suitable participants for a study of this nature.

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PUBLIC AND PUPILS' IDEAS ABOUT RADIATION: SOME LESSONS FROM CHERNOBYL TO SCIENCE EDUCATORS

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1. Introduction

At the end of last year an opinion poll was held by Associated Press among foreign affairs journalists in 45 countries spread over Europe, Asia, Latin America and the Middle East, asking for the most important event of 1986.
A majority chose Chernobyl as the most important event before other important developments such as the failure of the Reykjavic talks between Reagan en Gorbachev and the change of power in the Phillipines. This illustrates that the accident in the nuclear power station at Chernobyl made a large impression on people in many different countries. Especially those living in Western Europe seemed to be afflicted by near-panic, especially from the moment that governments took action such as ordering farmers to keep cattle inside or to destroy some crops, and imposing food import restrictions.

Of course the Chernobyl disaster can be looked upon from various angles such as its effects on public opinion about nuclear energy, on safety measures at other nuclear power stations or on the prices of various fuels. Another possible angle is the educational one. In an editorial (15 May 1986) 'Nature' claims that a lack of general awareness of radiation and its potential consequences account for the near-panic. It mentions the general confusion about units of measurement, about irradiation and contamination and about the stochastic nature of many radiation effects. 'Nature' described the process of making radiation understood as an uphill task.
Anyone who might take up this challenging task can easily find literature in which results are described of studies dealing with public attitudes towards nuclear energy (Slovic a.o. 1979, 1981; Renn, 1981; Van der Pligt a.o., 1982; Baillie a.o., 1984). Most of these studies, however, deal only with the more affective components of attitudes. In order to improve education it is necessary to consider not only affective but also cognitive aspects of public ideas about radiation. Answers should be found to the following kind of questions: What do people mean by words like radioactivity, radiation, radiation dose and half-life? How do people explain the need and effects of certain radiation protection measures? What kind of misconceptions are common? Which scientific concepts are fundamental to a sensible assessment of radiation risks?
In this paper we will try to formulate some answers to these questions. We first describe some findings on pupils' ideas about radiation. In the following section we will outline how we have selected information from Dutch and British newspaper reports on the Chernobyl issue and how we have tried to get information on pupils' ideas about radiation within the Chernobyl context.

We continue with a presentation of some of our results and conclude with a discussion. It should be mentioned here that at the time of writing (January, 1987) the analysis had not yet been completed and therefore we intend to present the results of our full analysis at the Kiel conference itself.

2. Pupils' ideas about ionizing radiation

During the last decade many papers and articles have been produced on pupils' ideas about scientific concepts (Driver, 1985; Osborne and Wittrock, 1983). Most publications however deal with other areas of science than ionizing radiation, such as mechanics, electricity, energy and light. We might conclude from these studies that a major difficulty frequently arises about the meaning behind specific words. Osborne and Gilbert (1979) note: 'A student may give to a word a meaning which is subtly different from that intended. For example, if a student has a more limited, extensive or idiosyncratic meaning for a word than a teacher, the full implication of the teacher's message will not be realised'.

In the area of ionizing radiation we know of only two studies about pupils' ideas. Riesch and Westphal (1975) described their results of research among 58 German pupils of around 15 years old. From interviews with the pupils they concluded that most of them describe the propagation of radiation in terms of a 'current' or 'diffusion' model and not with 'particle' or 'wave' models. Riesch and Westphal detected a confusion between the transport of radioactive materials and the propagation of radiation and state that concepts such as 'radioactive contamination' contribute to this confusion.

Eijkelhof and Wierstra (1986) studied pupils' use of scientific concepts in a real life context: assessing the risks of applications of ionizing radiation before and after lessons around the PLON-unit Ionizing Radiation (1984). They conclude that pupils differ in their pre- and post-answers on applications with little public interest ('food irradiation') but not when the practical situations drew a great deal of public attention in the (near) past ('radioactive waste'). They also detected in the answers confusion between the concepts 'radioactive substance' and 'radiation', e.g. in expressions such as 'radiation accumulates in the body' and 'food becomes radioactive after irradiation'. The authors suggest that the popular Dutch term 'radioactieve straling' (in German: 'radioaktive Strahlung', litt.: radioactive radiation) contributes to that confusion.

The results of both studies suggest that in a radioactivity context pupils might attribute a different meaning to the word 'radiation' than the accepted scientific one. It is likely that this meaning is not a private invention of each pupil but founded on the use of this word in society, outside scientific and educational settings. Therefore it was decided (in February, 1986) to collect press reports about applications of ionizing radiation in order to study among other things the differences in meaning between 'lay-radiation' and 'expert-radiation'. After the accident in Chernobyl many of these reports were published within one month. We took the opportunity to make the Chernobyl information-boom the object of our research.

3. Collecting the data

As soon as the news about the accident reached the headlines (28 April) we started to collect our data. Within one month we had taped about 20 hours of radio- and TV-programmes: newsbroadcasts, informative programmes and discussions. As only those parts of the programmes were collected which dealt with Chernobyl these 20 hours contain parts of over 100 programmes. In addition to this, for a two month period we cut out all reports about Chernobyl, including news, background articles and letters from readers. Two were national papers (NRC-Handelsblad and Volkskrant) and one was regional (Utrechts-Nieuwsblad). Finally Dr. Robin Millar (University of York) provided us with newspaper cuttings from several British papers such as Guardian, Star, Sun, Sunday Times and Times.

Although our collection of tapes and cuttings is large it is not complete. Of course collecting and analyzing were very time-consuming so we had to limit ourselves. Furthermore it was not the purpose of this study to make a comparative analysis of the quality of reports in the press, but to investigate the meaning of 'radiation' and related words in daily life.

After the analysis of the above-mentioned press reports we devised a questionnaire for pupils of 15-16 years old in which we asked them to explain what happened in Chernobyl, why the Netherlands was affected, of what use certain government measures and advices were, and what the pupils meant by words such as radioactivity, half-life, radiation dose and radioactive contamination. The questionnaire was answered by 312 pupils from 7 different schools (two classes each).

4. Radiation in the media

From the press reports we selected over 400 different quotes which were not in accordance with accepted scientific theory about radiation and its effects. We classified them in five groups:

A. What happens at the reactor site?
B. Why did it affect those living in Western Europe?
C. Contamination of food
D. Contamination of people
E. General statements about radiation

In group A we find statements of the following kind: the Chernobyl reactor 'emits radiation', 'spews out clouds of radiation', 'leaks radiation' and this radiation 'has escaped', 'is being released', 'is pouring into the air', 'was seeping from the plant' and 'is catapulted into the sky'.

In group B we collected quotes which tell us that the radiation 'has spread across Scandinavia', 'is carried by the wind', so the radiation 'passes boundaries' and 'reaches countries which so far never were reached by radiation'.

Group C quotes describe effects on food. They inform us about the radiation from Chernobyl 'being deposited on the grass' and 'absorbed by the cows in their milk'; other crops 'were irradiated' so these also 'contained radiation' but 'the effect on water of the extra radiation was said to be insignificant'.

Group D contains quotes about effects on people: 'they are contaminated by radiation', 'they had contamination from radiation in their clothes' and 'accumulated radiation in their bodies'.

Fortunately there is iodine, which is 'an antidote against radiation sickness', 'prevents radiation concentrating in bodies' or 'counters the effects of radiation'.

Finally group E is filled with radiation remarks which cannot be classified in one of the other groups; we are told for example that 'iodine is found in radiation', that 'some radiation is older than other radiation' and that 'some radiation is short-lived'.

The above mentioned quotes and similar ones can be found in all the papers we studied. They illustrate that the word radiation is used in many situations where an expert would use radioactive substance. For lay people radiation seems to have a different meaning than the scientific one. We are not yet able to give a precise description of this lay-meaning of radiation, but we might conclude that lay people use the word radiation in a much wider sense than experts do and that they often make no distinction between radioactive substance and the ionizing radiation being emitted as a result of the decay process.

A consequence of holding this lay-view of radiation might be that one will not be able to make a distinction between contamination and absorbed dose of radiation and between activity and absorbed dose (i.e. between the units becquerel and sievert (or rem as was often used)). In the media we found numerous illustrations of this confusion, such as, 'food contains x mrem of radiation', 'a dose of 1000 becquerels'.

5. Some pupils' ideas about radiation

In most schools in the Netherlands radioactivity is taught when pupils are about 17 years old. So most pupils in our sample had had no 'schooling' in this topic.

As we have not completed the analysis of pupils' answers we will only outline in this section some general trends. According to many pupils the reactor 'sent radiation into the air' and this radiation reached the Netherlands because 'the winds carried the radiation' or 'the radiation was so strong that it reached the Netherlands'.

A significant part of the pupils used the word 'radioactivity' in the quotes mentioned above, instead of 'radiation'.

When we look at their answers to the question 'what is meant by radioactivity?' we find that a majority of pupils (55%) describe radioactivity as radiation itself. Only 11% denote it as a phenomenon or a property and 15% as a radioactive substance. This is significant as many science journalists use radioactivity meaning 'radioactive substance' assuming the public knows what it means.

One of the other questions asked about the function of iodine tablets in the Chernobyl context. Only about 10% gave scientifically acceptable answers. The others assumed that iodine 'neutralizes radioactivity', 'strengthens the body', 'acts against radiation' or 'filters the blood'.

Another question dealt with the advice given not to eat spinach during the first weeks of May 1986. Pupils thought that 'spinach absorbs a lot of radiation', 'contains too much radiation', 'has been irradiated', 'attracts radioactivity', 'was contaminated with radiation', 'contains iron which attracts radioactivity' or 'contains a substance which destroys the body's natural defence against radioactivity'.

From a first analysis of pupils' answers we might conclude that a considerable number of them use the lay-meaning of radiation which corresponds with what we found in the newspapers.

6. Discussion and conclusion

In the foregoing section we have tried to illustrate how lay people use the word radiation. They make no differentiation between the radioactive materials and the radiation emitted. This might explain why Riesch and Westphal (1975) detected a confusion between the transport of radioactive materials and the propagation of radiation.

As we found indications for lay-ideas about radiation both in Dutch and British newspapers one can conclude that it is not only language which causes the lay-meaning of radiation.

Some people may argue that in many cases it is not necessary to use the scientific meaning of radiation and that a clear distinction between radioactive substance, radiation and radioactivity is too complicated for the general public. We do not agree with this view for the following reasons.

It seems a reasonable hypothesis that many people who use 'lay-radiation' will assume that irradiating food does make the food radioactive: radiation is added to the food. This would of course blur any discussion about food irradiation. The same person will not be able to make a distinction between irradiation of a person and the ingestion or inhalation of radioactive substances: situations that can clearly have different effects on people and ask for different kinds of action. Such a person will also be at a loss with various kinds of medical applications of radiation which he or she might experience personally or through relatives or friends. One may think for example that an external γ-source makes a person radioactive as 'radiation is received'. And finally such a man or woman will be blocked to a further understanding of concepts which are essential for radiation protection such as half-life, radiation-dose (equivalent), decay products, absorption of radiation, etc. That person will be heavily dependent on the opinion of others and will be severely limited in asking critical questions in any radiation situation he or she gets into.

Which lessons should be drawn for science education? Teachers should take into account that their pupils might understand and use radiation in a different sense than the scientific meaning. By referring to many practical situations he or she could introduce the pupils to the fundamental scientific ideas about radiation. Essential in this teaching is to pay attention to the difference between lay-radiation and scientific radiation. Textbook writers should produce materials which support teachers in this task. However, many questions have not yet been answered. For example: which basic scientific knowledge is essential in which practical situations; which mental models do people use when dealing with various radiation applications; which other misconceptions limit a thougtful assessment of risks; what is the best way to teach radioactivity taking into account existing ideas on radiation? These kind of questions deserve a place on the educational research agenda. Answers on these question are darely needed, certainly for those who are in favour of STS-teaching.

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Dutch pre-university education

In the Netherlands pupils leave primary school at age 12. Those who want to qualify for university entrance remain six years in secondary school in the pre-university stream (called VWO). In most schools form 1 is not yet streamed. During the last three years (forms 4 to 6) pupils choose and study seven or eight examination subjects. Passing the (national) VWO-examination qualifies automatically for university entrance although some university departments require one or two specific subjects in the vwo-examination.

Relevance to Dutch Science Education

This paper deals with physics education at secondary level. The new examination programmes are likely to contain a considerable section on radiation effects and protection.

The authors

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IMPROPER ATTRIBUTION OF CAUSALITY - A POTENTIAL STUMBLING BLOCK FOR STS EDUCATION

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"Technological capability" is seen as being the integration of three discrete parts: First - intellectual and physical skills, second - knowledge of technological concepts, and third - the ability to make value-judgments throughout the design - decision-making process" (Harrison, 1985). It follows that lack of any one of these will stultify STS-education. However - unravelling science and technology's intricate relationships with social issues requires subjective elements of rationality, elements seldom found in science or technology education" (Aikenhead, 1985). It would thus appear that the success of STS education is contingent on pupils' attained "intellectual independence" i.e. "the capacity for making judgments about knowledge claims for oneself" (Munby, 1980) as e.g. the ability to discover "political motivation behind a smokescreen of scientific confusion" (Kantrowitz, 1975 in Aikenhead, 1985). "An individual judging the truth of a claim on the basis of all assumptions, evidence and arguments necessary for that judgment is exercising intellectual independence" (Mundy op cit). Obviously - an individual who fails to do so, or one incapable of doing so because he/she has not developed (for genotypic or phenotypic reasons) the capability, will remain intellectually dependent on authority. Hall et al (1983), while listing a series of cognitive skills, which are necessary (but not sufficient) for the success of STS education, state that "certainly it should not be assumed that (these skills) are already developed". What are these cognitive skills so widely demanded? Introductions to modern science-curricula (STS and non-STS alike), and other normative writings, contain lists of curricular demands in the cognitive domain, a few samples of which are given below: "To look for and identify logical fallacies in arguments and invalid conclusions" (Queensland Board of Secondary School Studies 1981), or to "develop the ability to think critically e.g. by seeking evidence for claims, applying cause and effect relationships, considering all available data and suspending judgment in the absence of evidence" (New South Wales Department of Education, 1983). The BSCS teacher's handbook lists - inter alia - withholding of judgment and the restriction of interpretations to the limitations of available evidence (BSCS, 1978). In Bloom's (1956) taxonomy, under paragraph 4.20 Analysis of relationships, we find "the ability to distinguish cause and effect relationships from other sequential relationships, to distinguish relevant from irrelevant statements, and to detect logical fallacies in arguments". Hodson (1985) referring to the "rhetoric surrounding science curriculum developments" states that "it is generally believed that children will best appreciate the activity of scientists by adopting a stance of objectivity, openmindedness and that (these qualities) desirable in themselves are transferable to other areas." More could easily be quoted.

This paper centres on two objectives: a. the ability to infer cause and effect relationships, and b. the developed habit of suspending judgment whenever the evidence for a claim is insufficient or lacking. These points are well taken by Arons (1984) and excerpts from his 10 points are given here: He contends that "teachers rarely consciously articulate (these points) or point them out to their students. They include:

a. Consciously raising the questions "what do we know?"..."How do we know?...'Why do we accept or believe?...What is the evidence for?" when studying some new body of material or approaching a problem.
b. Being clearly and explicitly aware of gaps in available information... Recognizing when one is taking something on faith without having examined the "how do we know?, Why do we believe? questions" or the evidence in favour of the assertion.
c. Drawing inferences from data, observation or other evidence and recognizing when firm inferences...regarding cause and effect cannot be drawn i.e. being sensitive to the control of variables."

And from Lawson (1979): "Hypothetico-deductive strategies operate in the cognitively mature individual (i.e who has reached the Piagetian formal stage E.J) as part of an overall process of thinking which has its aim the linking of events in terms of cause-effect relationships. The linking of events in terms of causality is basic to explanation... (however) recent data indicate that only about 25 - 50% of the late adolescent and adult population (in the U.S.) have well-developed use of the more complex hypothetico-deductive strategies." (emphases added)

That only parts of the STS target-populations at the secondary and even the tertiary level ever reach the Piagetian "formal stage (or its equivalent according to other theories) seems to be well-documented (see Shayer and Adey (1981) for the U.K., ASEP (1972) for Australia, Chiapetta (1976) for the U.S.).

The problem of cause and effect relationships has been succinctly described by Frankenstein (1976):"One of the ultimate aims of ...teaching is the weakening of dependence on chance-association... Separating the emotional component of 'time' from its purely cognitive element means: ... understanding time 'within which' certain events take place that are not necessarily connected by links of cause and effect".

"Attribution theory is a theory about how people make causal explanations, about how they answer questions beginning with "why". It deals with the information they use in making causal inferences and what they do with this information to answer causal questions. Attribution theory has developed within social psychology ...,but it will also be clear that (it) is relevant to other fields of psychology...as a general conception of the way people think about cause-effect data" (Kelley,1973).

Improper attribution of causality -- in itself a logical fallacy -- can come about through the committment of other logical fallacies e.g.
a. Assuming that events which follow others are caused by them (post-hoc reasoning)
b. Attributing causality on the basis of an insufficient number of instances or cases (sample too small, in the extreme case a "sample of one".
c. Attributing causality to a factor or phenomenon on the basis of a non-representative sample (irrelevant or biased)
d. Imputing causal significance to correlations
e. Attributing causal significance to very small differences which might have arisen fortuitously
f. Attributing causality to mere tautologies.

We shall now have a brief look at "how -- certain people -- analyze simple cause-effect data".

The following items are taken from a test constructed to ascertain subject-behaviour when confronted with (among others) the logical fallacies enumerated above. The test is fully described in Jungwirth (1987). For lack of space only categories a, b, e and f will be referred to. These items intended for grade levels 9 and 11, will be seen to have "created problems" st the tertiary level and with practicing teachers as well.

Category "a" (post-hoc reasoning)

Some pupils grew tomatoes in the laboratory. One day they were watered with soapy water by mistake. Soon after purple spots appeared on the leaves. What is your opinion?

a. No conclusion can be drawn, since we don't know what kind of soap was used.
b. The soap caused the appearance of the purple spots since none had been there before
c. I often water my garden with soapy water, and never saw purple spots, so that cannot be the reason
d. I don't agree with any of these choices.

Option "b" represents the logical fallacy i.e. attributing causality to a preceeding event without sufficient data.

Category "b" - Insufficient sample

One bean-plant was grown at 10^{0}C and another at 25^{0}C.All other conditions were equal. After several weeks plant A was almost twice as high as plant B and better developed. What is your opinion?

a. The experiment shows that 25^{0}C is much better for beans than 10^{0}C.
b. It is well known that warmth is needed for plant-development, so the results could be expected
c. Some beans like higher and some like lower temperatures this explains the result.
d. I don't agree with any of these choices.

Option "a" is the logical fallacy i.e. attributing causality based on "a sample of one".

Category "e" - fortuitous differences

Pupils planted 300 pea-seeds: 100 at a depth of 4 cm, 100 at 6 cm, and 100 at 8 cm. All other conditions were equal.
89 seedlings sprouted from a depth of 4 cm
91 seedlings sprouted from a depth of 6 cm
92 seedlings sprouted from a depth of 8 cm
What is your opinion?

a. There are no insect-pests at greater depth, which might attack the seeds before sprouting
b. The deeper the planting - the better the sprouting
c. More information is needed about these seeds and soil
d. I don't agree with any of these choices.

Option "b" attributing causality to the "depth"-factor, in spite of the fact that the data indicate a "no difference" situation, represents the logical fallacy.

Category "f" - tautologies

It is well known that the animal body needs nitrogen. Why?

a. The animal body requires nitrogen as part of its body-needs
b. The animal cannot do without nitrogen, because it must have nitrogen to live
c. All animals must have nitrogenous foods, because their body requires nitrogen
d. None of these choices explains the fact.

Options "a" to "c" are non-explanations, since the explanans is on the same level of information as the explanandum, thus "saying the same thing in different words", which is the definition of "tautology".

Table 1 will show in what measure respondents were aware of and and able to avoid these logical fallacies by *refusing* to attribute causality to factors, conditions or situations, where the available evidence was insufficient or lacking (in the items quoted above and similar items). *See Table 1*.

We can see that *pupils'* (9th to 12th grade) *rejection* of options involving *improper* attribution of causality, or accepting such causality by implication, was -- with one exception -- at or below chance-level. Looking at (student-) teachers' results we can readily understand why pupils did not do any better. Only the post-graduate (student-) teachers' data approached a level which could just barely be called "acceptable" -- and even there a wide variability across categories was evident. Hall's et al remarks that teachers should not take pupils' attained cognitive skills for granted, can thus be expanded to include the teachers themselves. In Aron's (1974) words: "We force a large fraction of students into blind memorisation by imposing upon them ... materials requiring abstract reasoning capacities they have not yet attained, and of which many of their teachers are themselves incapable". Are these teachers indeed "incapable" or have they (like their pupils) just not been *made* aware of certain *simple* rules of critical thinking? Judging from discussions with both student - and practicing teachers in the countries concerned, it would appear that the latter is the case. Comments like "I have never thought of it like this before" were quite common. So there is still hope, *provided* that pre- and in- service teacher-education programmes attend to the matter, otherwise a vicious circle would be indicated. Holford (1985) says that "teachers expect that training should equip them with a better understanding of the quality of argument put in support of truth claims made in situations where science is 'used'-- for example in product advertisement and political debate." One wonders if these expectations are being honoured. The BSCS "Science, Technology and Society" curriculum (BSCS, 1980) includes activities for "technology assessment". Pupils' success in such activities seems to me to be contingent on (inter alia) pupils' awareness of and their ability to apply rules for causal analysis.

Let me conclude with a quote from Postman and Weingartner (1969): "Intellectual strategies for nuclear-space-age- survival -- in all dimensions of human activity -- include such concepts as ... probability, contingency, uncertainty ... *multiple causality (or non-causality)*... The learning of such concepts (and rules E.J.) will produce the kinds of people we will need to deal efficiently with a future full of drastic changes ... The purpose (of the new education) is to help all students to develop built-in, shock-proof" crap-detectors" as basic equipment in their survival kits". I fear that without these skills STS-education will stumble and fail, becoming just another subject-matter area to be rote-learned, and pupils will continue to be intellectually dependent on authority, being *un*able to "make judgments about knowledge claims for themselves". Certainly they will *not* have developed "technological capability".

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Table 1

Rejections of improper attributions of causality (rounded %)

Population	post-hoc reasoning	no sample	no difference	tauto-logies
Schools				
Israel (9th) N=114	25	2	15	11
do. (11th) N = 75	19	14	16	8
Australia (9th) N = 102	18	8	12	15
do. (11th) N = 80	34	12	16	26
South Africa (Soweto)				
10th, N = 166	15	9	10	not tested
do. (12th) N = 177	21	11	7	not tested
Adults				
Teacher-college students				
Israel, N = 35	41	14	41	34
do. Australia N = 23	55	24	25	28
Post-graduate student-teachers				
Israel N = 43	79	58	78	59
do. Australia N = 27	63	50	63	34
do. S. Africa, N = 10	55	40	50	30
Teachers in-service				
lower-secondary, Israel N = 20	54	22	34	11
do. mixed secondary, S. Africa (Soweto) N = 39	25	10	8	17
do. upper secondary Israel, N = 25	75	42	67	60

Note: All pupil-samples belonged to biology/science streams.
All adult samples were biology/science (student-) teachers.

I. Pre-university educational system in Israel

a. Compulsory kindergarten - age 5

b. Elementary school
   1. eight grades (age 6 - 14) OR
   2. six grades (age 6 - 12)

c. Secondary school
   1. grades 9 - 12 (age 14 - 18) OR
   2. intermediate (junior) secondary - grades 7 - 9 AND
   3. upper (senior) secondary - grades 10 - 12 (age 16 - 18)

Compulsory education ends with grade 10. Pupils sit for the matriculation examination in grades 11 - 12. For university entrance the matriculation grades are first renormed according to level of courses (6 - 9 - 12 - 15 classhours/subject over grades 10 - 12) and then combined with the results of the universities' psychotechnical entrance examination. Different "cut-off" levels are demanded by the various faculties, with e.g. medical and engineering higher than the humanities.

II. The paper has implications for the whole of the educational system, since habits of critical thinking must be developed gradually and progressively. Its implications for teacher-education are obvious.

III. Autobiographical notes

Born Vienna, Austria 1923. In Israel since 1938. M.Sc. Agric. (The Hebrew University of Jerusalem) 1951. Special studies in Agricultural Education and teacher-education, University of California 1955/56. Ph.D. in education (The Hebrew University of Jerusalem) 1962. Teacher of biology and horticulture (grades 6 - 12) for 12 years. Headmaster of secondary agricultural school for five years. Now Full Professor in agricultural and science education, The Hebrew University of Jerusalem and Senior Investigator (evaluation) at the Israel Science Teaching Centre (biology projects). Visiting scholar, Nuffield Foundation Biology Project (U.K.) 1966. Visiting associate professor, Monash University, Melbourne, Australia 1974/75. Visiting professor and consultant at the Science Education Project (SEP), University of the Witwatersrand, Johannesburg, South Africa, 1983 Guest-lecturer 1964 - 1986 at about 40 universities and institutions in America, Europe, Africa, Asia and Australia. More than 80 papers in various professional journals in science-education mainly in U.K. and U.S. Author of integrated text in "Agro-Biology" for secondary agricultural and rural schools.

SCIENCE AND TECHNOLOGY EDUCATION AND AFRICAN VALUES

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Introduction

How does the individual African look at science and technology in everyday life situations? What cultural meaning (value or worth) does it hold for him? These two questions relate respectively to "attitudes" and "values" in science and technology.

The relationship between science, technology and values has been commented on by many scholars[2] who generally agree that science and technology are cultural enterprise which exist in varying degrees in all societies; and that technology has reached a dominant position to the extent that the whole structure of some societies is dependent on a technological base. A highly specialized sub-culture (that of the scientist) has grown up.[3] Less agreement exists, however, as to the precise effects African cultural values have on the development of science and technology in general or on the potential of Africa in the fields of science and technology specifically.

Three Views about Science and Technology in Africa

One view put forward by scholars is that Africa lacks the capability and potential in the fields of scientific discovery, technological innovation and practical application. Odhiambo[4] for example asserts that:

> "Africa can be justifiably proud of its past technological achievement as revealed in recent archeological excavations and historical research into the civilization of Songhai, Mali, Zaire, Zimbabwe, Nubia and others. The fact remains however that the gap between the technological expertise of earlier periods and modern scientific achievements is such that the former cannot provide the base and perspective necessary now for the renaissance of African Science. If Africa is to make any contribution to Science and to its application to technology, then it must embrace those modes of thought and those tools of science that have been instrumental in ushering in the present technocratic age"

Odhiambo further argues that science and technology flourish most effectively through the use of "analytic methods" of investigation. This, according to him, consists of "the identification of a particular question and isolating it from a plethora of other problems in the same area"[5]. The appropriate tools of study are then focussed on this particular problem. Odhiambo perceives "the method" of science as requiring strict adherence to the principle of "objectivity" and to an assessment of whether or not the answers to the particular question fit into a known hypothesis.

On the surface, this view exhibits the pessimism that Africa lacks the intellectual environment that will stimulate the ascendancy of science and technology and the rationalistic (analytic) method which characterized Western intellectual history as in the 18th Century enlightment in France, for example. The view places great faith in the social efficacy of scientific methods and tools, and it, by and large, assumes a model of African society according to which science is the principal determining element in the shape and destinies of African people and their institutions.[6]

Below the surface, one may detect traces of African philosophical system as we associate with Mbiti.[7], Temples[8] and Jahn[9]. Mbiti for example has described African thought systems in terms of final causes or superstition, i.e. the belief in spiritual causes of natural phenomena and the irrelevance of hypotheses for advancing our knowledge of nature[10].

A second view sees modern science and superstition as having common grounds. In contrast, with the pessimistic view of Africa's scientific and technological scene this view holds that there is no basic difference between modern science and traditional non-Western mode of thought. Modern science and superstition both rely on models which are developed through thinking about observations of phenomena and are used to make predictions.[11] Elkana[12] summarizes this point of view as follows:

> "In certain aspects, African traditional thought and Western Science are analogous. (African) ancestors, heroes, waterspirits like atoms, molecules and waves werve an explanatory function ... all societies have spiritual as well as empirical daily concerns and that all cultures manipulate nature...
>
> It is a widely accepted image of knowledge that asserts that Western science seeks a mode of explanation through reference to a stable order. But is this actually so? Are explanations by Cartesian Vortices, Newtonian gravitational forces, embryological fields, pair-creation and anihilation, spontaneous radioactive decay, explanations through which a phenomenon is accounted for by reference to a stable order? I doubt it... I conclude that the basic difference between Western scientific and the modes of thought which have developed in other civilizations without 'science' is not a great divide, but rather a continuum"

Elkana's points are many here and amongst them are the following: that modern science and African mode of thought share common features. The crucial ideas embedded in the above passage is that no single "scientific" trait can be shown to be a distinctive Western trait confined only to modern western thought, nor does it obtain unqualified throughout the western world. "The difference between western and non-western modes of thought" writes Elkana "may be accounted for by Literacy and the educational experiences which influence the processes of thought of individuals and hence the collective representations which will prevail in a society"[13]

Clearly there are cognitive capacities which seem to be universal; present in all cultures. These capacities include the linguistic capacity, elementary commonsense thinking, and the ability to account for what happens in terms of observable events as well as in terms of unseen (spiritual) events and powers.

There is a third view which is of a quite different sort, however. This view holds that African social systems have been misunderstood because of a failure to appreciate what is implied by important differences between technologies of the major traditional states in Africa on the one hand and those of the European and Asian continents on the other. The sociologist Jack Goody has addressed this issue in detail in his book *Technology Tradition and the State in Africa*[14], pointing out that differences in modes of technology in Africa are connected with differences in other aspects of the social system[15]. Goody suggests that in order to understand the application of science and technology in Africa, "we need to take a closer look at the means and organization of production in Africa and Europe instead of tacitly assuming identity in these important respects. He identifies three interrelated aspects of African society which seem pertinent to technology and the state: (1) "the system of exchange (that is trade and markets) (2) the system of agricultural production (especially the ownership of the means of destruction)"

According to Goody, many parts of Africa were similar to Western Europe from the point of view of mercantile or monetary economy. Metal coinage was in use in East African coast. In the West coast, currencies consisted of gold, brass, salt and cowrie shells. Trade was highly organized and in the kingdoms such as Dahomey, and Ashanti, important sectors of the economy were under state control. Most of the kinds of economic operations that were found in pre-industrial Europe were also to be found in Africa. In goody's view, "except for specialized fields of wine and wool trade, external exchange in Africa was similar to that of Europe.[16]

Now turning to the system of production, Goody conceeds that Africa is basically a land of extensive agriculture. Although African mode of agricultural production was *extensive,* it was not *intensive,* and this was related to the nature of the soils, the labour force and the terrain. He asserts that one fundamental invention that spread through Euroasia that found limited use in Africa was the plough[17]. The use of the plough in Euroasia had a number of effects. First, it increased the area of land man could cultivate and hence made possible a substantial rise in productivity, at least in open country. This in turn meant a greater surplus for the maintenance of specialist crafts for the growth of difference in wealth and in life styles for development in urban non-agricultural life. Secondly the plough stimulated the move of fixed holdings and away from shifting agriculture. Thirdly, it increased the value of arable land. The plough was used to harness animal power for the labour of tillage. This was also of substantial significance. Human resources were substantially increased thereby, since for the first time, men tapped a source of mechanical energy greater than that which their muscles could supply. The use of animal power also established a much more integral relation with stock-breeding and agriculture. Mixed farming, uniting animal husbandry with crop cultivation was to become the distinguishing characteristic of agriculture in Western Euroasia. It made possible a higher standard of living or of leisure than was attainable by peoples relying mainly or entirely upon the strength of merely human muscles.

In the African forests, the plough had many limitations. First, the wheel, though it corssed the Sahara (as evidenced in the two-wheeled chariots liberally engraved upon saharan boulders) and was introduced in Europe and Sudan, it was never extensively adopted in Africa. This was not because of the lack of a metal technology, but rather, the plough did not improve vegeculture to the same exent as it did cultivation of cereals in Euroasia. Secondly, animal disease was a factor which limited the use of the plough. The limited use of the wheel, meant that man was not only unable to make use of animal power, but of the power of the wind and water as well. The lack of the wheel also limited the possibilities of water control.[18] As Goody points out, in the drier regions of the Euroasian continent the wheel played a dominant part in raising water from wells to irrigate the land. However simple irrigation was practised in many parts of Africa and consisted of channelling water from a permanent srping to run among the fields and this farmers got two crops a year instead of one. There was also the shaduf practised in several areas along the Saharan fringe which used the lever principle as a mechanical devices for drawing water. In Africa, there were also water storage systems in wells. Clearly while there was no lack of water in Africa, the problem of distribution was enormous.[19]

Perhaps, the most significant technological gap between Africa and Eurasia, according to Goody was in the military field. He notes that when the Portuguese spearheaded European expansion into other continents, they succeeded largely because of their use of gun-bearing sailing ships. At first they depended on cannon on their floating castles; later upon the hand-gun. By 1498, the armament of the Portuguese ships was something totally unexpected and new in the Indian and China seas and gave an immediate advantage to the Prtuguese. Through these they could dominate their African opponents who were armed only with swords, spears, and bows. By the end of the fifteenth century, when the expansion of Europe began, their guns were also far in advance of Africa as well. Goody, quoting Beachy asserts that "The Africans never seem to have learnt to make fire-arms as good as those of the Europeans unlike the Sixteenth-and Seventeenth-Century Japanese and Sinhalese, who soon achieved virtually parity with the Portuguese in this respect"[20]. He remarks that the reason for the failure of Africans successfully to take up the manufacture of this powerful new weapon was that "they did not possess the requisite level of craft skill in iron-work. As a result, Africans were at an enormous disadvantage when the scramble for their continent began, since they had to fight against the very people who were supplying them with arms.

However Goody's view is to be challenged here. According to Professor Onwuejeogwu,[21] recent research on the indigenous forms of technlogy in Africa seem to have shown that the Awka people in Eastern Nigeria made sophisticated guns in the eighteenth century by local smith working with iron; but these guns were prohibited by the British who saw the potentials of these firearms.

The third vew I have discussed above point to the variety and effects of technology on African institutions and values. In order to understand how the individual African looks at modern science and technology in everyday life situations and what Africans value most in science and technology, one must display an awareness of the social origins of even the crudest forms of technologies and also recognize the role of social institutions both in fostering technological development and in mediating between technology and its effects. Therein lies the counterargument of the third view about science and technology in Africa.

"The Techno-Cultural Gap"

Now, to turn to one of our initial questions: "how does the individual African look at science and technology in everyday life situations?" This question leads us to what Professor Ali, A. Mazrui[22] calls "The techno-cultural gap" of the Western colonial heritage in Africa.

In his book *Political Values and the Educated Class in Africa*,[23] Mazrui contends that colonialism was not simply a political experience but a cultural experience as well. The values of the African world were prodoundly disturbed by what would otherwise have been a brief episode in African history. He points out that through acculturation, the African, and Africans in general had come to acquire Western *values techniques* and *institutions* Mazrui puts it this way:

> "It is indeed worth accepting the distinction between values, techniques and institutions when we are exploring what Africa has borrowed from the West. The modern school itself is an institution so borrowed. The style of instruction, the general ethos of the school and the curriculum help to determine what values and techniques are transmitted within those walls. Techniques require an infrastructure of supportive values. This is particularly clear in economic behaviour. Certain commercial techniques from the west can only be transferred to an African society if there are supportive entrepreneurial values in the host society to sustain the techniques. Britain did not try to transmit either all its values or all its techniques to the colonies even if this were possible. Only some British values and some British skills were promoted in African Schools. But did these partial values match with the partial skills?. Given the skills which were being sought, were the African schools fostering the right normative orientation?"[24]

This quotation from Mazrui points to the incongruence that lay at the heart of the imported educational system in Africa. According to Mazrui, the wrong Western values were provided as an infrastructure for the set of Western skills introduced into Africa. The reason for this gap was due to the paradoxical role of the missionary school in Africa. On the one hand the missionary school was supposed to be the principal medium for the promotion of "modern civilization in Africa. On the other hand, Western civilization on its home ground in Europe had been going circular. In Africa, secular skills were given a religious infrastructure was rejected, there were no alternative supportive values for the new secular ambitions. As Mazrui noted "many schools taught the virtues of obedience instead of the ethos of initiative; they taught the fear of God instead of love of country; they taught the evils of acquisition instead of the strategy of reconciling personal ambition with social obligation"[25]

The techno-cultural gap has also influenced the way Africans look at science and technology. In Africa science and technology is seen as consiting of the "traditional" and the "modern". The traditional are those characteristics and features which are believed to have existed before the imposition of colonial rule. The modern are those characteristics and features which are derived or directly transferred from Western societies, ancient, medieval and contemporary.

Within these categories, there is continual resport to dyadic classificatory schemes. The following are some examples of this dyadic classifications:

traditional society	modern society
traditional science	modern science
traditional medicine	modern medicine
traditional healer	modern healer (doctor)
traditional (mystical) diseases	modern (natural) diseases
traditional treatment	modern treatment
traditional technology	modern technology

There are all sorts of ways the characteristics of "the traditional" and "the modern" are defined when used to characterize science and technology "Modern" is often viewed as good and desirable, and words such as "progressive" "efficient", "empirical" "innovative" and technologically "advanced" are associated with modern science and technology. "Traditional" on the other hand suffers negative associations: "out-dated", "conservative" and "fatalistic. It is commonplace nowadays to make distinctions according to country's technological development or levels of wealth. Countries in which widespread use is made of "modern science and technology are regarded as technologically advanced while those in which widespread use is made of "traditional" science and technology are regarded as backward.

Not only is it seen that these elements determine the nature of science and technology in Africa, but they also determine the nature of African societies and the direction to which these societies move. African societies are said to be underdeveloped and backward compared to Western societies. The major trend of the social and political systems of Africa today is seen as based on a scale from "underdevelopment" at one end, to "development" at the other. The main task of African social and political systems is said to be the attainment of "development; hence development fund, "development bank", "development plans" e.t.c. and the role of science and technology in African development.[26]

To many, science and technology are a progressive and change-inducing force. They are usually supposed to be a thoroughly modernizing enterprise. It is widely accepted that one of major roles of science and technology in Africa is to engender new knowledge, to enlighten, provide scientific modern explanations and rational approach to problems. The death of traditional values and ways of life, and the rise of new, sometimes unwanted ways are strong in the public imagination. Thus the idea of change from the traditional to the modern has been one of the modern has been one of the commonest ways of looking at science and technology in Africa.

But we have to be cautious about this view of science and technology in the African continent. First does science and technology really change attitudes, values and customs? For example has science and technology made Africans to abandon supposed traditional ways such as extended family system, or always prefer hospital treatment to traditional medicine? Secondly, the view of change from so-called traditional (underdeveloped) society to modern (developed) society is somewhat misleading in itself. What is development? Does African development mean making our societies more and more like the societies of Europe and North America whose characteristics, including the ancient, medieval and contemporary are seen as constituting "the modern"? But what exactly are these characteristics which make them so distinctive?

In fact, when we look closely at ways of life in industrial countries strong elements of tradition are still found. In Japan, for instance, traditional customs of parternalistic treatment of employees and of loyality to the business firm are still strong. In Britain, long-lasting respect for the monarchy and nobility illustrate the strength of traditional attitudes. These examples show that it is difficult to distinguish societies which are supposed to have wholly modern attitudes, sustoms, values and ways of life from those which are supposed to be more traditional[27]

Within African societies, it is also difficult to distinguish between "modern" and traditional phenomena. A rapid growth of "traditional" fetish houses and shrines for instance, may be a sign of the stress of modern life and of rapid social change. Cohen in his book *Customs and Politics in Urban Africa: A study of Hausa Migrants in Yoruba Towns* [28] has shown that apparently traditional tribalism among Hausa migrants to Ibadan is in fact a modern phenomenon. He found out that the Ibadan Hausa have recently exaggerated their extensive cultural identity and way of life in order to sageguard their strong economic interests in the cattle, kola and transport businesses. Thus what appears to be "traditional" may therefore turn out to be a recent phenomena linked to other economic and political factors. In terms of the day-to-day life situations in Africa, the "traditional" Vs "modern" dichotomy probably obscures much more than it illuminates the way the individual African looks at science and technology. The African person has indeed definite values which in important respect differ from those from Western societies. But the concepts of modern/traditional instead of helping us to grasp these significant differences only obscures them. 'The prevalence of these concepts in our thinking and discussion, the pervasiveness of the framework of analysis which they form a part of here, basically serves the purpose of increasing our feeling of inherent inferiority as those members of the human race who have to 'catch-up'. If at the same time increases the arrogance and influence over us, of Western societies as those who are to be caught up with and therefore set the pace and standard of human development.'

African Values and Technology Transfer

What are the major value orientations in African societies and what cultural meaning does science and technology hold for them? In order to understand the values of the African, we have to start from fundamentals and not start and stop at the level of appearances and conventional categories. Clearly some African values can be found in other cultures and not all Africans fully exhibit the typical African values.

The major social value of the African is his relationship with nature for the sustenance of life and the relationship he enters with other men in the course of this. These relationships are not optional. They are basic, permanent, daily and the foundations of the African society at all times.[27] These relationships enable us to understand African customs related to family life, food taboos, activity and work, achievement and success, moral orientation, humanitarianism, efficiency and practicality, science and secular beliefs, material comfort, progress and individual personality.[30] It also helps us to understand why Africans wear certain clothes; and relationship between the child and his parents, elders etc.

The fundamentals of African values are constituted by these relationships. The impact of science and technology on African values is thus a study of the assessment of the former on 'our thinking, health, work, living habits and individuality'. However, it is not yet feasible to develop a system of social indicators responsive to the values cited above for a way of measuring the full range of effects of technology. It is probable that attempts to assess, the effects of technology may appear to many to threaten African values. There is thus set up a tension between the need to expand technology in Africa and the wish to preserve our values which leads some people to conclude that science and technology is inherently inimical to African values. Yet, there are other important factors which influence what cultural meaning science and technology holds for the African.

At the centre of the effects of African cultural values on the development of science and technology, or on the potential of Africa in these fields is the process of technological transfer. As Mazrui[31] has pointed out, transnational firms have been the major media of transfer of technology outside the military field. The transfer takes place mainly in four forms. The technology is embodied in first, physical goods and equipment; secondly skilled labour; thirdly know-how which is generally recognized in patents and trademarks; and fourthly, knowledge which is either not patented or patentable.

G.K. Helleiner[32] sees a consensus emerging among analysts and some planners that the unpatentable know-how with respect to most forms of technology is of greater significance than the patented knowledge.

> "Technology payments in licensing and collaboration agreements in which patent rights are not involved typically exceed those in agreements in which they are. Knowledge embodied in the patent is, in any case, normally insufficient by itself to permit its efficient working (as Harry G. Johnson has put it) 'In contemporary conditions, public tolerance and legal protection of commercial secrecy has become more important than the patent system.[33]

Helleiner regards the effects of patents on technology as being restrictive, but a good deal depends upon the options available in a given situation. There are certainly occasions when commercial secrecy is an inescapable de facto alternative to patented knowledge - and the secrecy can be a worse constraint on technology transfer than the patent.

A substantial part of the debate about technology transfer in Africa has concerned the issue of "appropriate" technology. And within this issue the distinction between labour-intensive and capital-intensive technology has loomed large. The bais in technology transfer by transnationals has on the whole been towards capital intensity.[34]

While multinationals have played a major role in industrialization, mechanization and commercialization in Africa, the precise nature of the industrialization and commercialization has itself distorted certain directions of both cultural and educational values. The need for a new adjustment has become more urgent.

Implications: Levels of Technological Choice

In the discussion of African values in the preceeding section, I alluded to the tension imposed on African values by attempts to assess the effects of technological development. Africans will typically make judgements and choose to act in ways that reveal and reinforce African values. However as Mesthene has pointed out 'value changes may result from the effects of technology on religious belief systems'[35]. This means that the choice behaviour is determined or at least circumscribed by the options available to choose from at the time the choice is made.

Available choice options do change over time, of course. Today, Africa needs to make a choice in technologies at three levels. At the first level is the simple Village-Level technology which uses local materials, low-skilled manpower, and natural energy sources such as wind-mills and solar-powered devices. This technology produces rural self-sufficiency, and puts people to work in rural areas. Julius Nyerere, former President of Tanzania, seemed to have affirmed his faith in this level of technology when he said:

> "Our future lies in the development of our agriculture and in the development of our rural areas. But because we are seeking to grow from our own roots and to preserve that which is valuable in our traditional past, we have also to stop thinking in terms of massive agricultural mechanization and the prolefarianization of our rural population. We have, instead, to think in terms of development through the improvement of the tools we now use, and through the growth of cooperative systems of production. Instead of aiming at large farms. Using tractors and other modern equipment and employing agricultural labourers, we should be aiming at having ox-ploughs all over the country. The jembe (hoe) will have to be eliminated by the ox-plough before the latter can be eliminated by the tractor. We cannot hope to eliminate the jembe by the tractor.[36]

At the second level is the "intermediate" baseline or infrastructural technology. This is the technology that is needed to improve water supply, public housing, waste disposal, power distribution, transportation networks, telephone systems, hospitals and training and educational systems etc. This type of baseline technology requires widely available equipment and techniques such as pumps and valves, piping, electrical transformers and controls. Unfortunately, these items are currently being imported at very high costs by all African countries. It should be possible for African countries to acquire enough technical knowledge not just equipment to learn how to manufacture many of these items locally. There are thousands of African students at colleges and universities in Africa, Europe, Canada and the United States and several other countries in the Eastern world who are receiving highly specialized training capable of manning Africa's 'base-line' technological needs through a laboratory-intensive approach and a capital-intensive approach to produce needed machines and know-how. At the third level is the advanced technology, that would be needed to process goods which can be profitably exported or substituted for other forms of imports.

There are some African countries where technology has produced some outstanding results. For example, Nigeria has done quite a bit in developing its own technology which includes petroleum refining, steel production, and vehicle assembly and canning industries. In Kenya, there are factories which process coffee and tea. In Zimbabwe, there are industrial zones with large factories; while in Senegal there are industries for the dressing and packaging of fish. However some very difficult choices still have to be made on the type of technology that is most suited for Africa.

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21. See M.A. Onwuejeogwu *An Igbo Civilization: Nri Kingdom and Hegemony*. Ethnographica, London Ethiope Publishing Corporation, 1981.

22. Ali A. Mazrui *Political Values and the Educated Class in Africa* (Heineman London, 1982).

23. *ibid*

24. ibid, p^{23}

25. ibid, p^{29}

26. Based on Yusufu Bala Usman *For the Liberation of Nigeria Essays and lectures 1969-1978*, (New Beacon Books Ltd, London, 1979), p$^{232-240}$.

27. Kenneth Blakemore and Brian Cooksey (1980) *A Sociology of Education for Africa*, (London George Allen and Unwin). p$^{172-173}$.

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30. Note that Western Values such as equality, freedom, democracy, nationalism and patrotism have not been mentioned here. For an elaboration of this issue see Robin Williams "Individual and Group Values". *Annals* of the American Academy of Political and Social science, *Vol. 37*, (May 1967) p30.

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32. G.K. Helleiner 'The role of multinational corporations in the less developed countries' trade in technology' In *World Development* 3, 4, (April 1975).

33. G.K. Helleiner *ibid*, pp$^{163-64}$

34. G.K. Helleiner *ibid*, pp 169-71.

35. Emmanuel G. Mesthene *opcit*, p.^{49}.

36. Julius Nyerere 'The purpose is man' *Freedom and Socialism: a selection from Writings and Speeches, 1965-1967. Oxford* University Press, Dar es Salaam and London, 1968: p^{320}. See also Ali A. Mazrui Cultural Engineering and Nation Building in East Africa Northwestern University Press, Evanston, Illinois, 1972, Chapter 15, pp$^{247-62}$.

AUTOBIOGRAPHICAL NOTE

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NOTES ON PRE-UNIVERSITY EDUCATION IN NIGERIA

1. Education and Government

Since the publication of the new National Policy on Education in 1977 (and revised 1981) the Federal Republic of Nigeria has provided guidelines for Education in the country.

2. Primary Education

The National Policy recommends the re-organisation of the 6-year Primary School curriculum in line with the objective of a broad based education with emphasis on permanent and functional literacy and effective communication. The proposed curriculum will make adequate provision for agriculture, home economics and health education. The quality of teaching in primary schools will be improved through conducting in-service training programmes for unqualified and underqualified teachers already in service and the supply of adequate teaching and learning materials in schools.

3. Secondary Education

Secondary School is to be divided into two phases,

(i) junior secondary (3-years duration); and

(ii) senior secondary. Both phases aim at two main objectives consisting of (a) preparing and selecting pupils for the next stage of the education system and (b) preparing those who will not proceed to the next stage of education for employment and useful living within the society'. The new system involves a shift in emphasis towards pre-vocational and vocational training. Deliberate attempts are being made to de-emphasize boarding schools to give preference to 'day neighbour-hood-schools' as as to enable children attend schools closest to their residence.

4. Technical Education

Technical education continues, to command the priority attention of government. More technical colleges and vocational training schools are being built in order to increase training facilities for craftsmen, artisans and technicians. The existing polytechnics and colleges of technology are being strengthened and new ones built. In this regard it is the policy of the Federal Government to ultimately provide one technical college and one Polytechnic in each of the 19 States of the

Federation.

5. Teacher Education

The production of qualified teachers in appropriate numbers and subject areas is being speeded up to meet national demands. Emphasis is placed on the rapid expansion of the stock of qualified teachers at all levels and the enhancement of the quality of trained teachers through the provision of adequate equipment and materials.

6. On the Relevance of the Paper to the Nigerian Educational System

In Nigeria, as in most developing countries Science has now become a part of the Primary School Curriculum. Science is seen as a subject vital to national development. National and international conferences have been held, reports issued, projects established and curriculum materials produced - yet very little meaningful science teaching appears to go on in the schools. Why is this? Is the introduction of Science in primary schools premature? Are the teachers ill-trained to teach the subject? Or are the materials that have been produced out off tune with the African cultural environments?

To answer some of these questions, it is necessary to examine the general education background in which science is taught in schools and the impact of African cultural values on Science and Technology Education in Nigeria.

PHYSICAL SCIENCE, SOCIETY AND TECHNOLOGY :
A CASE STUDY IN THE SOCIOLOGY OF KNOWLEDGE

Peter J. Fensham (Faculty of Education, Monash University, Australia)

In 1986, the University of Melbourne, Victoria's (Australia) oldest and most prestigious university announced that the subject, Physical Science, Society and Technology was no longer an approved subject for students to include in their entrance score for any of its faculties.

Two grounds were given - the subject's form of assessment had an insufficient degree of externality to maintain the university's confidence, and the content of the subject was not worthy of the Year 12 standard.

This action by a powerful university against a minor science subject which, ten years after it was developed, still only had just over 100 students per year (in a dozen schools), compared with more than 7000 in Chemistry and 6000 in Physics (in 500 schools), may seem a strange one to report at an international conference. It is, however, I will argue, exemplary of the sort of difficulties that the S, S and T movement will encounter again and again as it seeks to influence powerful subjects in the curriculum like Chemistry and Physics. These difficulties are sociological in character and require socio-political solutions. Such a thesis raises new dimensions for science curriculum projects which have, in the past two decades, been accustomed to turn to psychological theories of teaching and learning to assist them with their perceived tasks, but not to give much attention to sociology.

The great curriculum revisions in science education of the 1960's and 1970's turned to several sources of help outside of science and science education. Psychology, one of these, was perhaps an obvious discipline to turn to as the study of learning has traditionally been part of it. Bruner, Gagne, Piaget and Ausubel are psychologists whose names and ideas are explicitly identified by many science curriculum projects.

There is, however, almost no reference in the literature and materials of these science curriculum projects to ideas or issues that derive from what can broadly be called the sociology of knowledge and education or even from the sociology of science. Furthermore, the programmes for the implementation of these science curricula - a highly social phenomena - were more often described in the language of industrial products, or personal change, or communication, rather than in terms of social roles or socially perceived meaning, or of social control, or of power and authority.

The Science, Society and Technology movement and its progress

For at least a decade there has now been a Science, Society and Technology movement which is concerned that science education, within the school curriculum, should include in its learnings aspects of the interfaces between science and society, and science and technology.

Although attempts to change science curricula in these ways are now sufficiently numerous that they can be said to represent definite progress, the main stream of high status science education in most countries is still scarcely touched by the S, S and T movement (see Fensham 1985a) There are clearly powerful constraints operating that need to be understood. In this paper the experience of a decade of one such case of a science course that very early in the movement espoused an S, S and T approach is used to identify several of these types of constraints, including ones that are epistemological, pedagogical, oganisational and educo-political.

This is not to say that there has been no sociological analysis of these curriculum projects and their use. Young (1971) and Layton (1973) in Britain and Connell et al (1982) and Fensham (1977, 1980) in Australia have argued that powerful social controls have been exercised in and through science curricula.

The risk of the Guardians of Scientific Knowledge

In the 1880's the Gifford lecturer in Edinburgh was arguing that natural philosophy (physics) had as much right as natural theology to be included in a university's range of departments - an argument that is strange indeed to identify with in the 1980's. It was, however, in the 1880's also, after a long debate about Spencer's advocacy in the 1850's of science as central to a general education, that the prestigious east coast universities (in the USA) helped to establish science in the curriculum of the high schools in that country. In doing so, they placed it in a subservient role to their own needs (a very different role from the one Spencer intended) by agreeing to base the selection of their entrants on learning achievements that included physics and chemistry (Showalter, 1975).

Since that time, chemistry and physics have become increasingly powerful subjects in the curriculum of schooling. Indeed, since the second World War (the final stages of which were dominated by their association with some of the most fundamental aspects of 20th century modern physics), these two physical sciences have held such supremely established positions in the curriculum of secondary schooling (as Latin and Greek held in the nineteenth century) that they have not needed to concern themselves with the meaning or defence of this supremacy.

Academic scientists from physics and chemistry have been the ultimate check point for deciding what knowledge from the physical sciences is worthy of being included in school science courses. This is true whether the influence is exercised directly (as tended to be the case in the NSF projects in the USA) or indirectly through school teachers thoroughly socialised through their own study at university (as in the British Nuffield projects).

Major curriculum projects for school secondary science have not been established under advisory or management committees of industrial or applied scientists. This has meant in practice that the decisions about what knowledge is important have been made in education's hierarchial sub-system for science - headed as it is by university scientists. Layton has used the terms "subject maintenance" for the way these science guardians exercise their influence. Not surprisingly, the outcome of these decisions, time and again in curriculum projects or revisions, has been a content for school chemistry and physics that is very consistent with, and preparatory to the type of chemistry and physics taught at university. This has even been so when the great majority of students who might, or do study physics and chemistry will not be going on to study these subjects in higher education.

The Case - an S, S and T Subject

By the mid 1970's the position of chemistry and physics as two of the three most powerful subjects in Victoria was unchallenged, but their popularity among senior secondary students had been declining for more than a decade. The proportions of Year 12 students in Victoria studying chemistry and physics had fallen from about 45% in 1956 to 27% and 23% respectively in 1976. One obvious (but naive) suggestion to redeem the popularity of these sciences was the development of a single weight subject in the Physical Sciences, and in 1975 a project was approved for this purpose. The outcome of the project was a new science subject for Victoria's Year 12 students that was entitled "Physical Science - Man and the Physical World".

The subject was approved (see below) in 1976 and first studied and examined in 1977. Several minor revisions in content outline and major revisions of its supporting texts have occurred in the first decade of its existence. Its basic structure, which set out to give overt attention to Pure Science, Applied Science and the Cultural Impact of Science has, however, been present from its inception. Its original sub-title inspired the developers and was meant to be a reminder to all that the course was a study of *the interactions between mankind and the physical world*, and not simply a study of the established knowledge in physics and chemistry that results from some of these interactions. In 1983 it was decided to change the name of the subject to Physical Science - Society and Technology - by now a more appropriate way to label its knowledge characteristics.

Approval: a Pyrrhic victory against the guardians

In Victoria, as in most other Australian states, subjects or studies in the final years of secondary schooling are conferred differential status in a variety of ways. The most powerful set of conditions are those associated with entry to the most prestigious universities and to their most socially desired courses and faculties such as medicine, engineering and law.

For example, some of the school Year 12 subjects are designated as ones that can contribute to a student's selection score. Secondly, certain of these subjects are recommended as background preparation for particular courses. Finally, a subject may be listed as a pre-requisite for a certain course and such subjects must be part of the learning performance that makes up a student's selection score.

Subjects to which one or more of these conditions apply have high status in the eyes of teachers (at school and in higher education), parents, and the community, and hence also of students. Indeed a number of other social institutions like banks, the government public service, and large industrial companies in Australia also use only a student's achievements in these sorts of subjects in selecting and appointing staff.

At the time when Physical Science was seeking approval for the first category above, it had to be independently approved by the three universities and by the Victorial Universities and Schools Board, the body that was responsible for the conduct of the examinations in this final year of secondary schooling. Strong opposition to the subject during its development had been voiced by some members of the Physics Department of Melbourne University, who at a very early stage approached the director of the project and offered support provided the project would declare that the purpose of the subject was to provide a terminal school experience of science education for those students who had no intention of going on with science studies in higher education.

By a chance coincidence the meeting dates for the Melbourne University Committee and the University and Schools Board coincided and the spokesperson of these powerful opponents chose to exert his influence at the meeting of the Board of which he happened also to be a member. His motion of non-approval was lost at the Board due to strong interventions by some of the schools' representatives. Meantime, at the simultaneous meeting at Melbourne University the subject gained approval.

This was not the end of the opposition however, and for almost a decade the subject's approval has been shackled. None of the universities in Victoria would list it in their publicity material in either the *recommended* or the *pre requisite categories.*

Furthermore, they pushed through the Board a constraint that said that Physical Science could not be taken with Physics or Chemistry. Since Chemistry (and in 1977 Physics also) is a *pre-requisite* for entering the Medical Faculties in Victorian universities, and chemistry and physics are *pre-requisite* or *recommended* for Engineering, the thousands of students who would want to hold open these prestigious courses as even faint possibilities have not been able to consider studying Physical Science on its intrinsic merits as a course of science study.

The subtlety of these constraints are such that the universities could continue to claim that they would accept students of Physical Science into their courses and faculties except for Medicine and Engineering but nowhere did they refer to it directly in a positive sense. Students, teachers and schools had to be very persistent to discover that Physical Science had this degree of social acceptance.

A second very severe social constraint on the teaching of Physical Science has been the interaction between these university conditions and the size of Victoria's secondary schools. Many secondary schools in Victoria are quite small with considerably fewer than 100 students in Year 12. Accordingly these schools were confronted with the agonising (but easy to decide) choice of teaching chemistry or Physical Science. Since neither their science student numbers nor their science teaching resources could justify both subjects chemistry always won, since to abandon that powerful pre-requisite subject was in effect for a school to render itself "non-academic". In one school with 12 science students, 10 wished to do Physical Science and 2 chemistry. When asked why the interests of the ten were sacrificed for the two, the school quoted the pre-requisite status of chemistry for Medicine although no one could remember when a student from that school had gained a place in Medicine!

At a much lower point of higher education's scale of status, it had been envisaged that the colleges that offered courses for the training of primary school teachers would welcome Physical Science since they have deplored for so long the fact that almost none of their students have studied either Physics or Chemistry in their final two years of secondary schooling. Alas in these cases, the college authorities were again unprepared to recommend or require Physical Science lest they were perceived by their potential applicants in the schools in an unfavourable light, and hence fail to fill their quota of new enrolees - an increasingly important condition for their continued funding as the Australian economy worsened from 1975 onwards and spending on higher education came under increasing scrutiny.

Clashes with the guardians

The Physical Science project team began in 1975 when the international energy crisis was well known if not seriously felt in Australia. It is thus not surprising that the team received a number of suggestions, from the wide range of pure and applied scientists it consulted, that a more substantial and realistic treatment of energy and the practical problems of its use should be included. Accordingly, it developed several units that were based on energy interchanges and transformations rather than energy contained, gained and lost. Work, in this approach, is thus not described as a form of energy, but as a mechanism of energy transfer. The core unit for these studies of energy was called Energy Transformations and another focussed on Engines and Fuels.

As these plans became known, criticisms began to emerge from sources involved in physics and chemistry. These took several forms. Firstly, the energy content in Physical Science was said to be inappropriate for a school Physical Science subject because it was not included in the current physics and chemistry courses (based on PSSC and CHEM Study as they were at that time). This particular criticism occurred so often that it became clear that these guardians expected a subject the content of which would be bounded by whatever was currently being taught in physics and chemistry. Another example for this criticism was the inclusion of polymers, wood and ceramics among the materials in the unit, Useful Materials, on properties and structure of materials. None of these useful materials were at that time ones that the school chemistry course used to teach its topic on the structure and bonding of solids.

A second attack distorted the practical discussion in the course of efficiency in the use of energy, into a claim that the subject was trying to teach secondary students the Second Law of Thermodynamics - a clearly inappropriate topic since it was taught in the first or second year of a university science course. Again, the interactional approach to the teaching of energy was attacked, despite its use and advocacy by a number of tertiary advisers. Again, it was not the one being used in chemistry or physics.

Finally, for this topic of energy (as in all course's topics) these guardians argued that the study of the social, economic and historical associations of energy that the course encouraged, was not appropriate in a course wishing to claim for itself the word "Science" in its title.

A schackled existence but a new threat

Physical Science - Technology and Society continued to exist between 1977 and 1986. It was supported by a loyal enthusiastic committee of teachers, tertiary science educators, and applied scientists. Each year, however, only a handful of schools enabled students to study it. Nevertheless, one of the tasks the committee had was that of setting the external examination that is required as a central part of the assessment of all subjects in the university entrance category in Victoria.

Thomas (1985 a and b), the chairman of the examining panel for a number of years, has recently outlined some of the ingenious ways in which he and his colleagues have learnt to devise items that encourage and assess the learning of the three broad themes of this subject. This decade of experience of examining S, S and T intentions for learning could be an invaluable aid to examiners in those several other countries that are now requiring part of national examinations in science to reflect more applied aspects of science and its social consequences (e.g. Britain and Kenya).

As the 1970's moved to the 1980's and significant numbers of young people faced the prospect of unemployment, the role of secondary schooling in Australia came under increasing scrutiny. Governments of conservative and socialist leanings in Australia both set up policies that aimed at much greater participation in full secondary education than had been the case in a country where many young people had traditionally left school between 15 and 18 and moved successfully into employment, with or without further part-time study. These policies highlighted more sharply the decline in the popularity of physics and chemistry and their elite position. Once again, questions have been raised as to how many more senior secondary students could be effectively engaged in studying the physical sciences.

The Physical Science course in Victoria in 1976, if unconstrained, may have attracted many more students (as intended) to the study of the physical sciences. It could, however, have undoubtedly also attracted many of the existing students of physics and chemistry to a point where their power bases were threatened. Accordingly, social forces emerged to control and severely contain it. In 1986, in quite new social circumstances, it was, even though so limited, a living model for the next major reform that was seeking ways to make the study of science mandatory for all senior secondary students. This time, discrediting by a powerful university was the social process used to protect traditional physics and chemistry.

Conclusion

A feature of a number of school science courses as ideas of S, S and T became more commonly known throughout the 1970's was the incorporation of phrases like "applications of science" and "social implications and limitations of science" into the detailed statements of course outlines for physics and chemistry. After the 1960's when many text books for the physical sciences at school were particularly a-social in their presentation (Fensham, 1974), revised editions or new texts in the 70's began to include examples of the applications of these sciences with varying amounts of detail.

Usually, however, these new emphases, or additional material, do not involve a re-ordering of the basic sequence in which the science was to be taught. The logic for the selection of the basic content and the sequence for its teaching and learning have remained that of the academic discipline and not that of the applications. Furthermore, the marginal character of these concessions to S, S and T were very clear if the examination papers for these subjects were analysed. Very little if any credit was available for learning the applied or social aspects of the science. The primary intention of the learning for the examinations was the orthodox conceptual and descriptive content of the academic science.*

Movements like S, S and T or Science for All (see Fensham, 1985b) seem to be trying for a more substantial reform of science education. However, the experience of Physical Science suggests that strong social forces of resistance will emerge if this reform takes certain directions. When it does, only a more compelling combination of societal interests will enable these resistances to be overcome and the changes to occur.

Some of these threatening directions seem to be now clear.

1. When an S, S and T science course is established that could complete in attractiveness with the existing physics and chemistry courses.

2. When an S, S and T science course includes (or suggests the inclusion of) science topics or approaches and aspects of science that are not included in the existing physics and chemistry courses.

3. When a S, S and T science course claims to be a sufficient basis of science learning from which universities ought to be able to accept students for courses involving physical sciences.

4. When a science course wishes to include social, political and economic aspects of S, S and T interactions as serious parts of the intended learning as distinct from contextual or motivational purposes.

5. When successful learning in an S, S and T science course seeks to compete with physics and chemistry for status such as is conferred by being the basis for selection into socially prestigious courses or professions.

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* The very recent developments in examinations reported above may indicate that the S, S & T movement has gained significant social strength in these countries.

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SCHOOL EDUCATION IN AUSTRALIA

School education in Australia is under the control of the eight separate states and territories, so that there are quite significant variations, particularly in curriculum.

In general, there are 13 years of schooling, P (preparatory year), 1 - 12. In some states primary schools inlcude P, 1 - 6 and in others P, 1 - 7. Some states also divide the secondary years so that there are junior high schools for 7 - 10 and senior high schools or community colleges for 11, 12.

Children enter the preparatory year (often after a year in kindergarten) between 4½ or 5½ years of age. They thus move into secondary schooling between 11½ and 13½, and into Year 11 at about 16. They complete the 12th year at 17 or 18 but increasingly these last two years of schooling may include older students who have had several years out of school.

The learning achievements in Year 12 have been the basis for university selection although this is now being reconsidered in a number of states. Assessment at Year 12 has traditionally been by an externally set and marked examination paper. Since 1978 in a number of states assessments carried out internally in the student's school have been an increasing component alongside the external examination. A number of students in some states now take courses that are based on a negotiated curriculum where self or mutual assessment is involved.

The paper makes clear where it fits into the system, namely, a Science course at Year 12 seeking status as a subject for university entrance.

AUTOBIOGRAPHICAL NOTE : PETER J. FENSHAM

I was trained as a chemist at Melbourne University and at Bristol University where I completed a Ph.D. in catalytic phenomena. After a post-doctoral year at Princeton University, I held a Nuffield Sociological Fellowship at Cambridge University where I completed post graduate studies in social psychology with a thesis on Human and Social Aspects of Automation in the Weaving Industry.

I held an academic post in physical chemistry at Melbourne University for 10 years until I was appointed Professor of Science Education at Monash University (also in Melbourne, Victoria, Australia). Since 1982 I have been Dean of the Education Faculty at Monash. My publications include a number of papers, books and reports on science education, environmental education, social justice in education and higher education.

WHAT IS STS ?

William Hall (Executive Director, TAFE National Centre for
Research and Development, Australia)

INTRODUCTION

STS (the teaching of the interactions of science, technology and society) is becoming respectable! There are university research departments, college courses, school and tertiary education curricula, and full-time evaluations all dealing with STS. However, STS is a discipline as yet to be properly defined and it has yet to develop concepts which are unique to itself. A great deal of research has yet to be done before STS can be assured of a secure place in science and technology education.

The purpose of this paper is to help push this research along a little by discussing two questions :

(a) What *is* STS?

(b) What *should* STS become?

I present a personal point of view and am deliberately controversial. I want to generate discussion at the symposium! It is my opinion that STS is in danger of becoming a minor aberration in education, taking its place with general science, environmental science and integrated science. It will do this because it lacks focus, is amorphous in its content, has not developed its own concepts or theoretical structures and is regarded as a soft option by academic students on the one hand and is seen as totally irrelevant to their future job requirements by less academic students on the other hand. Science teachers are generally antagonistic, or ignorant, or apathetic.

This paper deals with the two questions by describing the many interpretations of STS and then going on to propose a more realistic interpretation. This more realistic interpretation is developed by means of a detailed case study of the 'new technology'.

WHAT IS STS?

There are at least ten interpretations of STS. These are not mutually exclusive and all are briefly described below.

1. Social Implications

Teaching the social implications of scientific discovery or technological change was one of the first interpretations of STS. Indeed, social implications were taught for many years before STS was even thought about. Early proponents sometimes had left-wing tendencies (indeed, a leading social implications author of the 1930's was a Marxist).

The questioning of either technological "advance" or of science as life's elixir was regarded as radical.

Countries needed scientists and technologist and so most teachers thought that nothing should be done to frighten prospective students away. Teaching social implications, therefore, became a superficial description of scientific and technological achievement. There was no learned criticism: such criticism was left to long-haired radicals.

For example, students made messy things called plastics and then gazed at photographs of fashion models wearing clothes manufactured from artificial fibres. Descriptions of countless numbers of boring boron hydride experiments were justified by rocket photographs; and textbooks were liberally sprinkled with pictures of gas cookers, fields of maize and high speed electric trains. Science and technology were the answers.

Then pollution was discovered. Everyone scrambled on to this, including art teachers, social studies teachers and language teachers. Students staggered from one class to another to discuss, describe, paint, experiment and argue about pollution. No one could actually do anything about the problems but the feeling of concern was there and teachers believed that they were teaching something really worthwhile. Indeed, the whole pollution movement in science education illustrates how utterly pointless the teaching of social implications has become, reducing STS to a series of political slogans and with most of the social implications examples used by teachers being well removed from the spheres of influence of the majority of ordinary citizens.

2. Technological Applications

Technological applications of science have been taught for as long as there has been science education. Models of coal mine ventilation (as an application of convection currents) and Holmyard and Palmer's (fifty years old!) chemistry text with its industrial processes and barely legible half-tone photographs are well known to many of us.

One of the most elegant books written on technological applications is E.G. Richardson's "Physical Science in Art and Industry" (English Universities Press, 1940) published some twenty years before the big U.S.A. and U.K. science projects even began.

My main criticisms of this approach to STS are, firstly, almost always the technology chosen is 'academic' technology rather than the technology of every-day life and, secondly, only that technology relevant to the needs of big industry or commerce is usually selected.

For example, we need "captains" of industry and so technology is presented as an attractive, problem-solving exercise for the most able students. Unless you're going to be the Managing Director of (say) ICI, then this approach is seen as irrelevant. I once wrote a book just like that ("Science and Decision Making", Longmans, 1974) which I thought was the last word in STS education. It was not, because its examples, its approach, and its use, were all far removed from the students' present and prospective worlds.

3. STS

The equilateral triangle with science written at one corner, technology at another corner and society at the third corner, has become the banner of the STS movement.

There has been debate about whether a position inside the triangle has any useful meaning but, in most cases, the triangle has sufficed merely to represent "interactions" whatever they are, between science, technology and society.

In practice what this has meant is that instead of teaching just about the technological applications of science, or about the social implications, both have been taught together. This has usually been done haphazardly, superficially and mostly in ignorance of the real social pressures (such as political or economic pressures). This is not surprising because science and technology educators have had a narrow education themselves, and most would not have a clue about how major decisions are taken in (say) politics, economics or commerce. Nevertheless, in the belief that all people think and act like scientists or technologists (and with tortured academic debates about the differences between science and technology) we have STS courses produced which would make politicians and industrialists squirm with embarrassment at those places in courses where they themselves are mentioned.

In my talk to the Nottingham Conference held in 1982 I listed some of the problems I judged had to be overcome if STS were to progress. These problems were :

(a) lack of clear definitions
(b) lack of theoretical structure
(c) inadequate curriculum development procedures
(d) teacher resistance
(e) opposition of higher education
(f) pre- and in-service teacher education deficiencies
(g) paucity of curriculum materials.

Most of these still remain a problem and there has been no progress in some instances at all.

4. Science For Jobs

A fairly narrow interpretation of STS is that the purpose of a science or technology education is to prepare a person for a job and so STS should reflect this. The argument is as old as science and technology education, as is the counter-argument : that only a small minority of students will actually become scientist or technologists and so such an approach is indefensible. Nevertheless, some STS does seem to make such an assumption, basing its examples, or case studies, not so much on citizenship but on being a manager in industry. It is another example of the "captains of industry" approach.

5. Scientists as People

I can well remember the discovery by some of my Nuffield and Schools Council colleagues in the 1970's, when they surprisingly exclaimed that scientists were real life people (or long dead people). For some reason, the fact that a scientist had been a spy, or a member of a strange religious sect, or of left wing or right wing politically, was information which mattered a great deal indeed. The classical laws of science had to be shown to have real live people behind them.

Monographs were produced which gave life stories, placing scientific laws or discoveries into social and historical contexts. Industry was viewed as social groups, not just as collections of buildings housing the equipment and machinery.

Now this approach to STS frequently led to interesting case studies, but could hardly be seen to be remotely relevant to the immediate or future needs of most students. This approach in text books is now sometimes relegated to a box of text, plus photograph, separated from the real science and capable of being skipped by the disinterested, who wish to get down to the hard scientific or technological facts contained in a textbook.

6. Science for Citizenship

The first time I was faced with teaching science for citizenship was when, as a young teacher, I was presented with a class of arts sixth form students. They were timetabled for two lessons of science each week. When I asked the departmental head for the syllabus I was told to teach anything which kept them amused. At their first lesson they made it clear that they regarded their two weekly science lessons as a complete waste of time and I was challenged to do something which interested them. I tried all sorts of approaches, but the one which really fascinated them was the periodic table. So much for science for citizenship I thought!

Two of the good things about Australian schools are that they have always been comprehensive and the high degree of early specialisation known in the UK has been avoided. Therefore, it is common for a student not to decide whether to study arts, science or technology until the end of schooling. This means that some science may be studied by all students so the appalling deficiencies in general education can be avoided.

However, I am avoiding the main issue : what science is needed for 'citizenship'? Perhaps the new project based at Leeds University will help to throw some light on this. When a group of us considered the question some years ago, we came to the conclusion that very little science indeed (as it was then being taught in schools) was required by most citizens.

Emphasis should be on the technology component of STS and any science which is required should be of an integrated kind, not taught as separate components.

7. Impact of Science Technology on Society

Science and technology have influenced every component of our lives : politics, economics, art, religion, hobbies, communication and so on. One approach to STS has been to consider these influences. Unfortunately, the education received by most science and technology teachers does not adequately prepare them to teach STS in this way. For example, how many readers of this paper could give even a superficial answer to the question : What were the effects of the industrial revolution on painting?

8. History and Philosophy of Science

History and philosophy of science used to be taught as a somewhat esoteric, academic subject and those teaching it would not have regarded themselves as STS proponents. Nevertheless, history and philosophy of science can be used as a vehicle for STS.

9. History of Technology

The history of technology has become a part of popular culture. There are now impressive museums of technology (both indoors and outdoors) which give STS examples on a grand scale. School project work sometimes uses local industries to build up a history of technology and the integration of school subjects within a project can produce first class STS material. Unfortunately, such interesting work is frequently confined to the Primary School.

10. Problem Solving

There is a plethora of books on the principles, psychology, theory and application of problem solving. One model, which was used by a project in which I was involved, is the Gagne learning model which in the act of combining principles, to form a new principle in order to solve problems, did draw on STS examples and material.

Real world problem solving can be an STS activity; laboratory problem solving rarely will be. Some technology projects have attempted to achieve a broad approach to problem solving, but many approaches have been contrived.

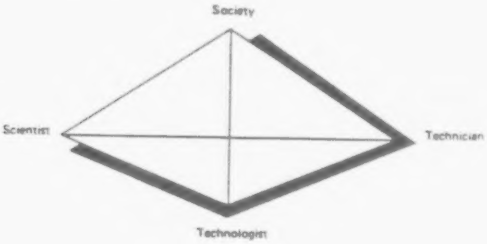
Any of these approaches to STS have this in common: they are generally superficial once outside the science or technology components and they are not relevant to the future needs of most students. The next section of my paper suggests how lack of relevancy may be overcome.

WHAT SHOULD STS BE?

The approaches to STS which have been outlined above all have the same weaknesses :

(a) the approaches taken and examples used within these approaches do not touch the lives of most students;
(b) courses are usually "academic" (even when written for the less academic);
(c) those involved in producing courses have themselves, had little or no experience of work outside the classroom and this is reflected in the approaches themselves;
(d) there is rarely a balance of science and technology and society as that balance occurs in everyday life.

What can be done to overcome such deficiencies and what should be the approach to STS? I would like to suggest that STS should in fact be STTS : the interactions of the scientist, the technologist, the technician and society :



It is at the technical level that most of us meet the technological applications of science. Few people will become scientists or technologists, many more will become technicians or will be involved quite regularly in technical activities in their homes. Few will interact directly with scientists or technologists, all but the very few will interact with technicians (such as plumbers, electricians, computer operators, garage mechanics). And almost everyone will be involved in technical activities of one sort or another for most of their lives, with most of those activities including a problem solving component to them. This involvement can range from mending fuses through to rebuilding vintage cars as a hobby.

How to Teach STTS

One way of achieving this approach to STTS is to build the curriculum around those vocational skills which will be required by the majority of students (as compared with the tiny minority of students who benefited from such an approach described in the first part of this report). The starting point in developing such a science curriculum should be to ask what skills a student will find useful in the home, in future jobs and for leisure activities. These skills will embrace knowledge, attitudes and manual skills. It will be argued that there is little new in this, but I would counter the argument by pointing out that what has actually happened in science education bears little or no relationship with what I am suggesting. (One approach to STTS will be described in the talk.)

What we need is a partnership of "educators" and "trainers" and there is every indication that this is starting to develop in Australia. The "education" versus "training" debate is a non-productive one. Training, or skills without knowledge, has some meaning for labourers who are involved in repetitive activities in their jobs. This is a fast declining area of occupations.

Almost as spurious as the education/training debate is vocational/personal development dichotomy. I do not wish to underestimate the importance and value of programmes (e.g. expressive arts, humanities) that have as their objective personal enrichment and educational liberalism. But to assume that vocational education is devoid of personal development is fallacious except where the teacher is unsatisfactory. For many tertiary students the greatest potential for personal development is via vocational education.

All good education appeals to the head, the hand, and the heart (those who prefer jargon know these are cognitive, psychomotor and affective aims). To concentrate exclusively on the "hand" will produce unthinking, moronic machines. To concentrate exclusively on the "head" will produce people capable of doing little which is of practical use. The "heart" must be catered for if we want our society to be humane. And in these difficult times, a humane approach is of paramount importance.

STS has failed in all of its approaches (as described in the first part of this paper) to appeal to the majority of our students. Pure science education continues on its aweful way. In its present form, it would be better not to have science education in secondary education at all, than to continue with what is presently taught. STTS then, with a proper balance of all components and without an undue emphasis on (say) the technical aspects, could make science and technology education far more attractive to students (and to politicians!). One example of this will be given in the talk.

AUSTRALIA: Pre-university educational system

Compulsory schooling 5-15 years (grades 1-10) with grades 11-12 completed for higher education entrance. High school (wholly comprehensive) starts at grades 7/8. Tertiary entrance is school-based (Queensland) or mixtures of external examinations and school-based assessment.

Tertiary sector consists of universities, colleges of advanced education (CAE's), and technical and further education (TAFE) colleges.

This paper is concerned with upper secondary/TAFE.

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FORCES HINDERING THE INTRODUCTION OF STS EDUCATION IN SCHOOLS

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Many aspects of human activity have been bombarded with innovations and undergoing changes which have become part of everyday life practically throughout the world. Attitudes towards change and innovations are far from being universally or regionally uniform as a particular innovation may be considered as a blessing by some people and a curse by others. Science and technology have contributed heavily to innovations and change and have enjoyed high prestige and wide popular support until the middle of the century. Slowly, many societal problems and issues related to poverty, environment, horrors of war, hunger and food resources, population growth, insecticides, carcinogens, toxic waste disposals and, lately, problems related to drugs and genetic engineering revealed to considerable segments of the population in a number of countries a different and ugly view of science and technology. The limitations and fallibility of science, scientists, and those who apply science could no more be ignored or overlooked. There were cries calling for providing the public with better and more honest information about the pros and cons of science and technology. It was with this fundamental goal that the Science-Technology-Society (STS) movement took off.

Educational systems worldwide have been known to be conservative and to evolve at a very slow pace. Forces hindering innovation and change can be found even in situations where generous funding backed the efforts to induce educational changes. For example, of the numerous science curriculum development projects of the sixty's in the U.S., those which deviated significantly from the curricula being replaced tended to have limited success. This was particularly true when the curriculum development project constituted a threat to well-established courses like physics and chemistry or when the change involved courses that had the potential to infringe on these. To illustrate, ISCS, an intermediate school science program, filled a gap and relatively was quite successful but ISIS which had the potential of replacing the traditional courses of biology, chemistry and physics hardly had the chance to take off.

Science, Technology and Society education seems to have gained considerable grounds during the past decade. The IOSTE, in general, and its special interest group known as the STS Research Network (STSRN), in particular, played a significant role in contributing to a greater appreciation of STS education and to recognition of its importance. One of the arguments in favor of the introduction of STS in schools is the need for an informed public to contribute intelligently and in a responsible manner to decision-making in problems related to the impact of science and technology on society and their interrelationships. This is hopefully achieved through making students aware of the long-term consequences of developments in science and technology. Another argument for the introduction of STS in schools revolves around the fact that in many countries the science being taught is not relevant to the needs of the majority of the students but aims at preparing for the future study of science at the university level. This is so in spite of the fact that very small percentages of students reach the university and, of these, only a fraction specialize in scientific fields.

Commitment to STS is on the increase at least at the oratory and declaration of intent levels. This is reflected in the frequency of reference to STS in presentations and discussions during meetings and conferences related to science education. The Second Technological Literacy Conference which was held in the Washington D.C. area in February, 1987 addressed the role of STS in promoting technological literacy as well as the ethical and value implications of science and technology. There were about 600 registrants, about four times the number in the first conference. In the March 1987 annual meeting of the American NSTA, there were at least 17 scheduled presentations whose titles directly suggested that an STS issue is being addressed. One of five principal recommendations of the Exeter II Conference reads as follows: "Science-technology-society materials and approaches are essential to the meaningful reform of all courses in the science curriculum" (Brinckerhoff & Yager, 1986, p. 26). According to Penick and Yager (1984), the U.S. "National Science Foundation is emphasizing technology education as an equal partner with science education in order for students to understand new technology and its role in society." The Center for Education in Science, Technology and Society of the Pennsylvania State University has secured funds from the GTE Education Foundation to support graduate fellowships and teacher scholarships in STS education for graduate students who intend to continue a teaching career in STS. These grants were started for 1985-86 and have been extended for the 1987-88 school year. In the United Kingdom, the report, **The Public Understanding of Science**, by a Working Group for the British Royal Society provides support for STS education and emphasizes the role of formal education systems in determining the public's understanding of science (STSRN, Nov. 1986). The STSRN Missives of February and November, 1986 include information about a wide range of STS activities, publications and production of related materials by individuals, groups and institutions in several countries that include: Australia, Canada, F.R. of Germany, Holland, India, Israel, Italy, N.S.W., Tamil Nuda, U.K., U.S.A., West Bank and Zambia.

The battle for an respectable position to STS in the school curriculum has not been won in spite of the eloquent and positive pronouncements and the mushrooming activities. The proponents of STS material in the school curriculum face many problems especially at the time of implementation and any success in permeating the traditional science disciplines of physicis, chemistry and biology has been minimal, in my judgment. Experimentation and trial of new ideas are more acceptable when their impact is marginal like when STS courses replace elective courses of physical science or possibly earth science - courses which have not been established in the mainstream of college preparatory courses. Furthermore, STS movement does not seem to have gained much ground within the educational systems of developing countries. My thesis is that proponents of STS face many difficulties in the process of introducing it to schools. What are the major forces hindering this introduction?

The problems facing those who strive to introduce STS into an educational system as well as the forces that stand in the way of its introduction vary widely and depend upon the magnitude, the level and the context in which STS is introduced. For example, if 5 to 10 % of a chemistry or biology course content is to be substituted by STS issues, the opposition is likely to be minimal when compared to a situation in which a full-fledged STS course is presented as a plausible replacement for these. Another variation in problems and approaches stems from the system of education in the country, whether it is centralized or not. In centralized systems, government officials in the Ministry of Education have to be convinced about the change and, once they and their superiors are convinced, the innovation is likely to be sweeping covering a whole country. A further complication stems from the fact that enthusiasm for and interest in STS as an important component of the school curriculum vary widely among regions, countries and educational systems and, sometimes, whithin the same school. Notwithstanding all these variations and differences, the following seem to be major and common forces that hinder the introduction of STS in schools:

a) Conservative nature of educational systems.
b) High esteem accorded the disciplines of physics, chemistry and biology in their traditional forms.
c) College/university requirements and the overriding importance of external examinations and the priority of topics that are covered by the examinations.
d) The teacher element which can be exemplified by the resistance of teachers to lose or dilute their well-established control over subject matter.
e) The unfamiliarity of teachers with the required teaching models and approaches.
f) The nature of the STS material which tends to be fluid and tentative when compared to the "clear-cut" information style of traditional science courses.
g) Lack of scarcity of textbooks and instructional materials in the STS field.
h) Position of community and interest groups.

It is clear that the outlined forces/problems that hinder the introduction of STS in schools are not mutually exclusive. Efforts will be made not to duplicate as these points are being discussed and elaborated in the following sections:

a) Conservative nature of educational systems

"Educational innovation is a politically charged issue and the continuity of educational policy is highly dependent upon political continuity and stability" (Crossley, 1984). The process of change involves initiation of the ideas for change and presenting them convincingly to those empowered to adopt them. These steps are followed by implementation and continuation after the novelty factor is out or, in many centralized systems, after the Minister of Education has been replaced with a change in the cabinet. When a system is functioning smoothly and is stable, there will be hesitation to delve into the unknown and rock the boat. Introduction of STS may be considered as disrupting to the existing order. By tradition, educational institutions have been entrusted with the preservation and transmission of the culture and the inherent societal values and, as such assumed a conservative stabilizing force in society. Under such conditions, there have to be cogent and convincing reasons for change that are to the satisfaction of those concerned. It also helps if the budget is not adversely affected by the proposed changes and if concrete and sound proposals for implementation are made available. The degree of receptivity to change has to be assessed with respect to all those who need to be convinced and the list may include politicians, school officials, teachers, parents, students and the general public.

Developing countries may be approaching educational innovations with more caution than in the past for several reasons. For example, many such countries have not reaped the anticipated economic and social consequences of their heavy investment in education. From another angle, many developing countries have patterned their curriculum development practices after experiences in developed countries and found out later that many curriculum innovations were condemned in their countries of origin. One lesson that may have been learned is opting for small-scale pilot projects or trials. It should be pointed out, however, that a successful small-scale trial does not necessarily guarantee a successful wide-scale replication especially recognizing that key and enthusiastic individuals who usually play a major role in trials cannot be available on the same scale and commitment in country-wide replications. Innovations may be accepted rather easily in situations reflecting instability or dissatisfaction or under conditions of disenchantment with the status quo. For example, the major criticisms to which education in the U.S. has been subjected recently may provide fertile ground for innovation and change (refer to **A Nation at Risk,** 1983).

b) High esteem accorded to the disciplines of physics, chemistry and biology

Latin, greek and geometry have been taught in the middle ages and until the turn of this century in order to sharpen the minds of students. The science disciplines may have contributed at least a partial substitute for these through the declared objectives of critical thinking, problem solving and scientific approach. For a long time, the success stories of science have been heard in much louder tones than stories of failure. A student who has pursued the academic route in the secondary school and who has studied all the science offerings has increased his chances of entering the university and of being considered for enrollment in any field of study, especially the socially desirable professions. All this esteem and prestige cannot be dismissed easily and efforts to tamper with these disciplines are likely to arouse strong opposition.

c) College/university requirements and examinations

Introducing STS materials as part of an intermediate science curriculum may not create problems if there is no external examination stressing material other than STS. A number of developing countries do have external examinations at the end of the ninth grade. The picture changes towards the end of the secondary cycle as students in practically all countries have to compete in examinations whose results determine promotion or admission to colleges and universities. With this in mind, it is understandable why students, parents and school officials give great importance to university requirements and will not sacrifice or compromise traditional academic standards for the sake of innovations. In order for STS materials to gain ground in the college-preparatory secondary curriculum, it has to be recognized either directly or indirectly by universities and be covered in the external examinations that affect admission to universities and placement in demanding fields of study. As the situation stands at present, STS courses have the potential of successfully competing with courses taken by the non-science oriented student in lieu of other courses that may be classified as non-college preparatory. In the U.S., the recent trend of requiring more science credits for graduation from high school may open the door for the introduction of STS courses for the benefit of students who have traditionally shied away from the traditional science disciplines. The challenge is to find ways and means to inject all types of courses - college-preparatory or not - with doses of STS materials in ways that enrich traditional courses and make them more relevant and interesting without diluting the requirements for those who would like to pursue higher scientific studies.

d) The teacher element

Science teachers have generally been more successful in teaching facts and in providing students with information than in developing the processes of science and promoting scientific thinking. They have cut for themselves a respectable portion of the school curriculum that is highly demanded for tertiary study and that purports to require relatively high aptitudes and skills when compared to courses in the social sciences or humanities. In spite of the uncertainties of science, the answer to a question in the science class is generally clear-cut; it is either right or wrong. The teacher knows his subject matter within limited boundaries and enjoys authority and a dominating position in the classroom. STS materials in the curriculum tend to threaten this prestige that has been enjoyed by the science teacher for long and to challenge the teacher's expertise. Furthermore, STS programs are not compatible with the interests and aspirations of many teachers partly because these programs do not seem to relate directly to the conceptual framework of the science disciplines. It may be considered demeaning to require the science teacher to tackle curriculum materials that can be taught as effectively by the social sciences or the language teachers. From another angle, the subject matter is so fluid and open-ended that it requires models of teaching and approaches that are foreign to the science teacher and, for which, he has not been prepared. In light of this, it is natural to expect the average science teacher to resist involvement with STS. If forced, teachers may pay lip service to externally-imposed curricular demands. Including topics in the curriculum does not guarantee changes in classroom instructional procedures to match the objectives underlying the curricular changes.

The preceding presentation points out the possibility that STS may diffuse the traditional role of the science teacher. Wilson as cited by Olson (1985, p. 302) notes that one of the consequences of role diffuseness is confusion and uncertainty. In talking to teachers in the U.K. who were using an innovative science project (integrated science) produced by the Schools Council, Olson found out that "teachers faced a dilemma associated with the loss of influence they experienced when they tried the inquiry approach to science teaching which the project favoured." Olson pointed out also that most of the teachers faced problems illustrated by the following: did not know how to construe a discussion; were concerned of the absence of clear-cut evidence that their job has been done; problems related to the unclarity of the syllabus, e.g., "the more teachers stressed how to think scientifically, the less they had to show for it"; teachers were faced with the prospect of teaching material not familiar to them; complaints were voiced from parents, employees and universities for a variety of reasons with the result that headmasters began to withdraw institutional support for the project; and, finally, all the project teachers were accused of not preparing acceptable candidates for advanced level science.

Some factors that hinder the wide adoption of curricular innovations and that touch the role of the teacher were described rather well by Shipman (1974) in the following conclusion of his report on the Keele Integrated Studies Project in the United Kingdom:

> Every innovation requires more skill from teachers.... The pioneers and the enthusiasts they attract can make the innovation work, can produce the results that make early evaluations positive, and can serve as a seed bed for its spread elsewhere. But the spread of an innovation involves increasing numbers of teachers who lack the skills and the enthusiasm of the pioneers. The promotion prospects of involvement in an innovation are also rapidly exhausted and the ambitious soon look to the next bandwagon. The result is that an apparently successful innovation in the hands of the few can fail when generally adopted or diluted.

To conclude this section, it ought to be stated that, in addition to the need for inservice teacher programs revolving around STS programs, the new generation of teachers should come to the classroom well-equipped with the information and the skills that are needed for the appropriate teaching of STS materials. Again, an encouraging note comes from teachers' associations, as the NSTA 1984 statement entitled "Standards for the Preparation and Certification of Secondary School Teachers of Science" stipulates that the program for preparing secondary school teachers of science shall be designed to develop among other objectives "a breadth of scientific literacy which includes not only subject matter knowledge but which also incorporates (a) applications and implications for action, (b) prediction of consequences, (c) analysis of value involved, and (d) responsible decision making."

e) Unfamiliar teaching models and approaches

Teacher tend to teach the way they learned. According to Bolster (1984), "teachers' knowledge of teaching, once achieved, tends to be highly resistant to change." Teaching of STS materials calls for a wide variety of approaches and skills that are unfamiliar to the average science teacher and that are different from methods usually utilized in teaching science disciplines. In STS classes, teachers are called upon to be managers of communications - guiding discussions, seeking alternatives and clarifying them, evaluating points of view, helping students to examine the pros and cons of each alternative, weighing the expected consequences of actions based on the different alternatives, etc. Teachers need to acquire debating tactics and learn the art of how to monitor discussion flow and to encourage group interaction. The requisite instructional strategies are quite varied and may involve the following singly or in different combinations: guest lecturers, library investigations, community surveys, debates, mock parliament, simulation games, role playing, field trips, critical analysis of print and electronic journalism as an example, problem-solving, activities that train in decision-making, etc.

Many questions are faced by the teacher as he is involved in teaching STS materials. These can be illustrated by the following: How can I develop the students' awareness of the consequences of certain specific developments in science and technology? How can I make sure that a balanced point of view is presented and maintained in discussions and that both positive and negative sides of an issue are presented? How can I maintain class discipline and, at the same time, encourage arguments? Should I express my own point of view about issues? If I do, would some students try to side with me on controversial issues, either during discussion or on examinations, in order to gain my favor in the form of grades? These are troubling questions especially to the novice. Discussions may become very touchy and sensitive when they deal with values, mores, norms and beliefs. In some of the issues that are likely to be discussed, the teacher and each of his students may have a certain meaning of events stemming from previous experience, peers, the home, TV, etc. - meanings which are products of social interaction. Proponents of STS education are apt to be gratified if as a result of discussion of ideas, commitment is built because ideas are being reformulated through the process and discussion represents group effort in understanding and applying the new idea (Crandall, p. 27).

f) The nature of the STS materials

One goal of STS education is to prepare science and technology literate citizens for the world of tomorrow. This is done through the identification, review and analysis of real-world problems related to science and technology and spotlighting the interactions with and impact on society. More often than not, the emphasis seems to be on the negative and problematic effects of technological developments on society. STS education covers a wide variety of topics including history, philosophy, economics and politics and it is taught from many different logical and ethical points of view. "For most of those who are involved in it, STS education must seen as varied in its goals, scope and methods as science itself..." (Ziman, 1980). In STS education, content, goals, standards and norms are still being developed. Because of the fluid nature of STS issues and materials, these may never crystallize. Unlike the science disciplines which can be taught through more or less a universal content, priorities of STS topics may vary greatly from one region/country to another. Topics found is STS curricula can cover a wide spectrum and can be illustrated by the following: insecticides, carcinogens, improved strains, biotechnology, medical engineering, lasers, war technology, nuclear reactors, solar energy, energy conservation, management of resources, preventive medicine, disease control, abundance of food supply vs. famine, pollution, smog, acid rain, toxic waste disposals and sewage disposal. (Searles, 1984).

The lack of a clearly defined syllabus creates significant problems for classroom teachers and for students. Teachers lack the means of evaluating the progress of students in a tangible manner and students do not know how to prepare for examinations. As mentioned in a previous section, in some schools technological issues are discussed in the social sciences class or in the language class. One teacher of junior high school English in Pennsylvania uses an interdisciplinary approach in her writing class by assigning students to write papers on topics such as the use of animals in laboratory research. The students love it, she reports, but the other faculty members think she is out of bounds. (Rothman, 1987).

g) Lack of scarcity of textbooks and instructional materials in the STS field

Certain materials have developed as part of the experimental drive of many pioneers in the field, for example, Ziman in the U.K. and Aikenhead in Canada. Yet, to a large extent, the classroom teacher is far from having instructional materials that will enable him to give a sound STS course. Some may argue that the nature of STS education does not lend itself to the limitations and boundaries of a textbook. Be that as it may, the fact that materials are not on the market and are not easily accessible to teachers is another deterring force hindering wide adoption of STS education. From another angle, the wide variation ot topics that are to be covered makes it particularly difficult to prepare materials that are relevant in different countries or different regions within a large country. The situation is likely to change when generous funding backs the production of STS materials or the STS enrichment of science discipline textbooks.

h) Position of community and interest groups

A number of problems may arise when controversial issues become an everyday classroom affair. Students with different backgrounds arguing about issues under the same roof are very likely to continue these discussions at home and elsewhere in the community. Problems and misunderstandings are likely to surface and differences of opinion to be voiced inducing uncalled-for reactions from a variety of sources at home and in the community if not from officials.

Communities and governments have traditionally expected from teachers behaviors and judgments which fall in line with the predominant cultural values, mores, beliefs and practices. This sensitive cultural heritage poses a deterrent against teachers' involvement in discussions of controversial nature in the classroom or in school. Some communities and governments may not welcome an outlook which presupposes that norms and attitudes are subject to change in light of rational thinking and evidence. Even in developed countries like the U.S., some communities oppose certain teachings about evolution and get the backing of courts to ban certain books from school libraries.

It has often been said that the images of desirable society are circumscribed by the image maker's cultural background. Although human experience tends to be unified by the spread of technology and the unity of science, scientific and advances and approaches are not necessarily welcome in all cultures and places. There may be a contradiction between a specific culture and the estiablishment of a viable scientific policy. Some developing countries consider that their heavy reliance on imported technology has caused them more problems than it solved. Thus, the position of communities and interest groups towards STS issues may vary widely from one culture to another.

Conclusion

The barriers to the process of innovation have been generally classified into four categories of value, power, practical and psychological conflict. It will be interesting to go through the exerecise of trying to sort out the problems raised in this presentation with their subdivisions within these categories. Innovation always involve objectives that in the case of STS may touch upon special political, social, or economic variables. The Ministry or Department of Education, the politicians, universities, school officials, teachers, parents and students - all share power in one way or another in running the schools and in shaping the curriculum. Does the introduction of STS involve any power redistribution? Are the teachers being involved and convinced or are they being coerced? With respect to practical conflicts, many of these are reflected in the paper and they need to be resolved if STS is to expand and take roots as an educational movement. With respect to psychological factors, it will help if school administrators and teachers feel that changes originate with them or, at least, if they are part of the decision. This is difficult to achieve in centralized systems but, even then, teacher groups may be represented in decision-making meetings. Teachers have to be convinced in order to accept change and cooperate.

Crossley (1984) points out that alternative educational options which pass with little criticism when practiced on a small scale may face great opposition when attempts are made for their widespread adoption or extension. With respect to the introduction of STS education in schools, several questions may be raised such as: At what school level is the teaching of STS issues optimal regardless of other considerations? Shouldn't the student possess certain functional knowledge of science and technology in order to benefit from and contribute intelligently to discussions of societal issues? What type of STS materials are in the domain of science and are best taught by the science teacher and what types are best taught by the teacher of social studies or language or civics? Can the science teacher who generally failed to achieve the objectives of promoting scientific and critical thinking through teaching the science disciplines realize these goals and the inculcation of scientific attitudes through STS teaching? How can teachers implicitly or explicitly refrain from inducing their own values, beliefs and preferences into the teaching-learning process?

In the process of teaching, teachers are forced to make numerous decisions related to classroom management - sequence of presentation, whether to give an unannounced quiz or not, to lecture or to discuss, what type of disciplinary action to take, to use verbal directives or silent cues, etc. Teachers' decisions are based on predictions from experience of anticipated consequences or most probable consequences. Compare such decision making with the relatively awkward situation when teachers may have to take an implicit or explicit stand regarding environmental and societal issues related to science and technology - issues involving acid rain, nuclear plants, nuclear warheads, specific genetic engineering problems and the like. Teachers are forced to lead discussions in these issues, follow new approaches in teaching and tread unfamiliar ground.

There are differences in outlook towards STS issues in different countries. For example, science and technology may be unpopular among certain sectors of the population in different countries for their role in destroying simplicity of life and in creating environmental problems. As mentioned earlier, STS curricula are not as universal as the traditional science disciplines because problems and values are not the same worldwide. It could be that the models and approaches of teaching are the same but even this may be subject to question. Discussion and debate and challenging the teachers are not likely to be favored in an authoritarian society. In some other countries, it may also be taboo to subject certain cultural issues - religious or political - to the dissection table. Officials in some countries may have their reasons for not wanting to open up wide debate in schools and universities on topics that come under STS because the process may end up criticizing prevailing conditions and threatening the system and the establishment. Layton et al. (1986) refer to science as a "multi-faceted resource capable of serving both conservative and radical purposes. At one extreme it was used to confirm religious beliefs; at the other, to undermine them..."

In the Technology Literacy Conference referred to earlier, "many of the science educators acknowledged that institutional barriers, such as teacher resistance and tests and textbooks based on the traditional curriculum, stand in the way" (Rothman, 1987). However, it is possible that the problems will be overcome as more and more leaders in education give active support to the STS-style curriculum. Evidence of such increasing interest and involvement may be detected by the participation in the Second Technological Literacy Conference which revolved around STS of university presidents, outgoing and incoming presidents of NSTA, chief education officers of the AAAS, and participation of education department officials from some states. It is also interesting that the National Council of Teachers of English was one of the sponsors.

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EXAMINATIONS ON CONCEPTS AND SKILLS IN SCIENCE-TECHNOLOGY-SOCIETY COURSES

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Abstract

The principle of perceptual continuity as a key feature of STS programs is presented. Examinations centered on this principle should test for skills in information gathering, synthesis and analysis, communication and persuasion, choice of position and action on issues encountered in STS courses and put less emphasis on factual knowledge.

Introduction

For severeal reasons, science and technology curricular at all educational levels are under attack. Politicians, especially in developing countries, faced with massive enrollments in lower educational levels and few higher education opportunities have called for terminal curricular to replace those curricular designed to step-wise prepare pupils for further education [1-4]. Programs designed to meet this challenge have, as a central theme, the interactions of science/technology and the culture of the societies in which they are based (STS). In developed societies, scientists, technologists and some special interest groups faced with electorates which are least prepared to deal with thorny issues of nuclear war, nuclear power, environmental protection and pollusion or population management, have pressed for interdisplenary courses which expose pupils to science, technology and society issues [5-8]. Although most of the evolving STS programs appear to be in the formative stage and sharp criticism has been leveled on some [1,3,9] the reception of the concept of a course in science/technology/society education by pupils, professional and governmental groups is generally warm [8-13]. Professional societies such as the American Chemical Society are supplimenting these efforts with public science and technology educational programs on television, radio and print media [14,15].

Besides the above reasons, there are other developments such as job market saturation and discoveries at the interface of certain fields e.g. chemistry and engineering, medicine, economics which mitigate subtly in favor of interest in STS.

For the most part, misgivings have been directed to the traditional practice of compartmentallized teaching in which pieces of human knowledge are isolated and labelled chemistry, physics, biology, economics, ethics, mechanical engineering etc. and taught as such to generation after another without due reference to the interactions and implications of knowledge in one compartment to that in the rest. Although, such compartmentallization is a useful tool in the efficient and effective management and communication of the vast amount of knowledge human activity has generated, its fragmenting effect in the process of intellectual activity may have undesirable consequences when real. To gauge the progress in science and technology, the chemical abstract service published by the American Chemical Society offers a prime example. For 65 years (up to 1971) chemical abstracts service published a total of 5 million abstracts of chemical and related research articles and patents [16], but withing only 13 years thereafter it published another 5 million abstracts. With this being typical of other areas, even further compartmentallization should be expected in the future. The task of STS courses therefore, is not to abolish the compartmental boundries but to develop skills which will allow pupils to make bridges between them, thereby utilizing the full human potential in exploiting mother nature and fruits of intellectual activity for survival.

At the 3rd International Symposium on world trends in Science and Technology Education, I described briefly how Tanzania was developing STS-type chemistry courses while maintaining a rigorous chemistry curriculum at the secondary school level [2]. In that report, I mentioned briefly, the problems we were facing with setting examinations in the STS-type courses which were making their way into the curriculum. In this report, I shall eleaborate on my experience and views regarding tests and examinations in STS courses.

Examinations and STS Programs

Examinations are important in curriculum development, they boost the prestige and status of the curriculum among teachers, pupils, school administrators and parents, especially when they demonstrate that the candidates are learning and understanding important concepts and skills. Examinations influence the way courses are taught and the concomitant conceptual and methodological emphasis. If a course is not examined, it will not be taken seriously by most people even if its benefits are invaluable. Examinations are therefore a teaching, learning, evaluation, and public relations tool in curriculum implementation. However, these important roles are well played if the examination items are of good quality and clearly targeted to important principles and skills the courses seek to impart.

In order for STS courses to be taken seriously, they have to find themselves a place not only in the curriculum but also a respectable one in the examination system. It is encouraging that this has began to take place too [2,17,18]. When setting examinations on STS courses, one attempts to identify concepts, principles or skills which are STS in nature. Quite interestingly, STS courses can not be compartmentallized in ways chemistry or physics are on the basis of the uniqueness of its principles, concepts or skills needed to master an STS program. Concepts covered under most STS programs are those found in chemistry, physics, biology, engineering, political science, civics etc. [1,2,6,17-19]. But the distinctive feature of an STS program is the principle of perceptual continuity which allows all aspects of a concept to be studied without regard to barriers established by the compartmentallization of knowledge. STS programs therefore do not come with new concepts in schools but bring with them a new pedagogy which cultivates skills for performing intellectual processes and survivalistic manipulations of mother nature in a perceptual continuum. Under STS, students learn skills needed for making bridges from one field of knowledge to all aspects of human culture and this is the core of good STS examinations. STS is not a new science or branch of knowledge but simply a strategey for delivering science and technology education in a way that forestalls the compartmentallization shortcomings mentioned earlier.

Testing Concepts and skills in STS

To throw further light on the principle of perceptual continuity as a guiding light of STS courses and examinations, let us consider the concept of human reproduction. The scientific fact is that the reproduction process (procreation) begins when a sperm fertilizes an egg- no regard to where this occurs i.e. in a womb (rented or otherwise) or laboratory dish. Technological facts are that the process can be mediated by human activity to facilitate it if fertilization encounters difficulty or stifle it if postponement of procreation is desired. In the latter case even if undesirable fertilization occurs, the technology to terminate it with a reasonable safety margin exists. The social facts are that sexual intercourse the commonly used route to fertilization is also used for recreation, the expression of mutual affection, love and collaterally as a source of income irrespective of whether procreation is desired or not. The other social facts are that there are laws, constitutional guarantees, religious opinion and value judgements regarding the practice of sexual relations and its attending consequences.

When the human reproduction concept is taught as an STS course all these aspects must be covered. The coverage should not just be limited to factual scientific, technological and societal issues knowledge, since in fact these are available in a liberal biology curriculum. But students should be trained in information gathering skills, such as chosing and reading a variety of good literature on the subject, carrying out interviews with experts, interest groups, parents, students, professionals and religious personnel. They should be trained in separating matters of scientific facts (i.e. knowledge aquired by the method of science) and beliefs. They should be trained in synthetic and analytical skills so that they may examine antagonistic and complimentary relationships between issues of science/technology/society. Using the information gathered and their analytical and synthetic skills they should be able to take a stand (whatever) and defend it using the scientific methodology. They should be trained in communication and persuasive skills both in writing and speech. They should be trained in the identification of avenues of action e.g. writing or telephoning their legislators, putting up posters, form, join or support interest groups etc..

For examination purposes therefore we are not only interested in factual information but also in a demonstration of familiarity with the above mentioned skills with which students bridge all aspects of the reproductive concept. We are not interested in what stand or action a candidate decides to take, whether it is for or against contraception, for or against bombing abortion clinics or burning down bath houses or prostitution centers. But rather as examiners we are interested in whether the candidates' analysis leading to his stand or choice of action demonstrates mastery of the relevant facts (scientific, technological and societal) at his/her cognitive level and the skills refered to above. We therefore should not take cover under factual examination items to avoid controversial confrontations over religious euphoria and value judgements. Factual examination will encourage the undesirable features of compartmentallized learning and teaching of STS courses. They are an essential ingredient in STS course teaching and examining but their importance should not be exagerated.

Factual aspects of STS courses can be extracted from candidates with objective type questions, but skills such as information gathering, synthetic, analytical, communication, persuasion, position building and choice of actions are better extracted using essay type questions.

To fully recognize and reward the candidates effort continuous assessment plays an important role. This is done by the teacher in a school right on the spot. The student gets feedback and has a chance to correct or improve his/herself before leaving the STS program. The main problem with continuous assessment is the variability of teachers' taste for quality of student responses, especially if examination results are used for career placement; but this maybe taken care of by statistical techniques at the national examinations center.

Most importantly the candidates should be told in advance what to expect on the central examination and should be trained in the knowledge and skills to be tested otherwise our efforts to develop STS courses will be hampered.

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Autobiography

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Pre-University Education System

Primary school education (P1-P7) starts at age 7 and covers a seven year period. Secondary education (S1-S6) starts at age 14 and covers 6 years. Less than 5% of the P7 graduates are enrolled in secondary schools (S1-S4) on the basis of a competitive examination and a quota system, while about 18% of S4 are later on enrolled in S5 on the basis of a competitive examination. University entrance is open to qualified S6 graduates and is based on good scholastic achievement on the S6 final examination or equivalent qualifications. The complicated system involving 2 years of working experience, recommendaitons from the employer and the ruling party local officials [1] was dropped. My paper deals with S1-S6, and fits in research and development.

SCIENCE AND TECHNOLOGY EDUCATION WITH A FOCUS ON VALUES AND ITS IMPLICATIONS ON QUALITY OF LIFE

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We seem to be essentially confronted with **"Cultural Contradiction"**, for we have created and are perpetuating in the schools a society which conflicts with out humanness and which may produce unintended consequences. This mutual contradiction is manifested in the tension which exists between our humanness (the need for self-actualization) and the demands of a complexity of formal organization. The dilemma seems to be whether or not man will dehumanize himself through the creation of a technological environment and its consequent social arrangement. This cultural contradiction is also paradoxical in that the immense promise of happiness and 'well-being' inherent in the industrialized technological society comes at the expense of humanness for the member of that society. Metaphorically stated, to our great God Progress we must sacrifice our humanity in order to receive the fruits of happiness it has to bestow upon us. The God Progress, with his angelic aids Industrialism and Technology, demands that we develop a 'one-dimensionality' in our efforts, and that we above all else dedicate a large portion of our energies to producing the high priests of scientists and technologists and their supportive personnel.

In the opinion of the author, there is a great danger in science as a singular values system, for if the weakness of non-industrialized nations is their resistance to scientific thinking, then there has been equal stubbornness on the western scientific thought to be over committed to technology. The western attitude towards science education concerning developing countries is exemplified in the following paragraph.

If we could teach the uneducated peasants' children to think logically, that is scientifically, to bring them into the 20th Century and get them to abandon their obviously unsuccessful peasant custom they would be better equipped to handle the problems and live more productive lives.

The trouble with this type of thinking however, is that there is enough truth in it to validate the demands for more technological education, but also enough over simplification to trap the wary into believing that indeed technology is a complete system of thought and therefore the key to solving developing countries' problem.

Thus, the introduction of newer curriculum in science (emphasizing theoretical science and western scientific values) like CHEM study, PSSC, BSCS from the United States does not solve the problem of science education since not single curriculum seems likely to meet the needs of rural students from developing nations. These may cater to the needs of the urban students, however, it appears that something further is needed to meet the needs of rural people. In the opinion of this author, rural students in developing countries do not need a theoretical science course, but, a practical science course related to students' daily lives and their values systems.

Importance of the integration of developing countries values with western values in science education has been described by the educational commissions of various developing countries. For example, the above conviction has been substantiated by the Indian Education Commission in the following paragraph:

> If science is to be pursued with full vigour and renaissance, it must derive its nourishment from our cultural and spiritual heritage. Science must become an integral part of our cultural fabric. It is possible that when science takes root in native soil and is no longer an exotic plant, its growth pattern may be visible influenced by those features which have been characteristic of Indian Philosophic thought and civilization. Part of Science's 'fashion' may be set by us reflecting Indian ethics and values judgements. Let us also remember that thinking and creativity has a considerable amount of the preconscious.

No stretching of ideas of science should therefore lead peasant culture of developing countries to conclude that their entire past life has been a lie and that their value system must be entirely replaced by one from an alien culture. It the idea of science can be comprehended in this context it means an extended dimension to their modes of thought. Only then can the people of our developing countries be free to accept the idea of a scientific literacy and not fear domination by it.

Coming to the specifics of this paper entitled 'Science and Technology Education with a Focus on Values and its Implications on Quality of Life', it may be imperative to discuss the primary aim of science and technology education in the developing countries especially in rural schools at the secondary level.

The primary aim of science and technology education in schools in developing countries should be to serve the future, i.e. to provide the students with knowledge as a tool for the improvement of their own living. The designed curriculum in science should have a practical application in the student's daily life in order to meet this aim.

Thus, the new system of science and technology education should enable young students to develop skills and acquire knowledge which will produce a better way of life for them in rural life, which will make it possible to lead the students to the discovery of knowledge. The science and technology programme should be aimed at raising the level of scientific knowledge, skills, and attitude of the students to allow them to be more productive in their home environments.

All this above discussion implies a new perspective for science and technology education in the school system. SEABORG aptly suggests that the new perspective of science and technology education should be to humanize the focus and feelings of science while at the same time organizing and rationalizing the forces of humanity. This suggests designing of a science and technology education curriculum in schools with reference to human values and social problems so that they will be more relevant to the needs of people.

Unfortunately, the perceived needs of society have not been the actual needs, as we are becoming painfully aware. To satisfy the actual needs of people involves a radical reformation of the process in which children become adults, for, it seems to me, the conflict between our humanness and the pressures of our technological organizational society must first be resolved in the schools. We must, so to speak, make the schools relevant to the human values.

However, the author realizes the importance of science and technology education in reshaping their future in developing countries.

The author's above conviction is substantiated in the following paragraph:

> Technology is the means by which man adapts the environment to suit his needs and by which became and remains human. It is an attitude of mind which has now evolved into an intellectual discipline, confining itself to no specific area and using all other disciplines to achieve its ends. As an element in the school curriculum it provides a method for the solution of problems, and enrichment for individual subjects and a link relating them to life and to each other. It is concerned with the practical activities and the stewardship of the real world and by confronting pupils individually and in group work, with ideas and first-hand experiences that are of immediate relevance to life, it helps to match theory with practice.

Concerning quality of life, it may be worthwhile to mention here that there are several essentially different dimensions of reality which every individual must learn as part of his general education; that each of these dimensions is closely related, even intermingling in some spheres but essentially different at the core and this requiring different ways of thinking to describe and comprehend them. That to properly evaluate all human experiences all of these modes of thought may be called into play depending upon the problem at hand. For instance: History is crucial, for past experience furnishes far and away the most abundant data from which we draw our daily judgements. In the individual sense this means merely memory, but for the community which is concerned with time periods longer than a single life span, the formal discipline of history is implied. The contribution of the fine arts cannot be dispensed with for they make us conscious of our emotional reaction to events and also provide vacarious experience far beyond our ability to actually have those experiences in the course of our real lives. No emotion is more influential in effecting our behaviour than that of actual experiencing of an event.

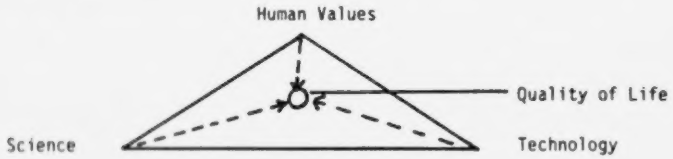
The idea of science and technology is, of course, infused into both of these other modes of thought but only for the purpose of furnishing objective data. Here it is the machinery of the universe, or simply its physical operating mechanisms that we hope to comprehend. This aspect of the world is explained by the workings of atoms and molecules and their sub-parts. It is because these basic particles are internally interrelated to one another like the gears of a clerk, one driving the other that a blue print can be made of their operation. And once a set of conditions are described or set up we learn that cause effect relationships are as sure as one dear driving another.

Finally, how are we to find meaning in our lives, formulating long range goals to free the individual from the tyranny of day to day experience: be motivated to overcome apathy and fears; change and grow toward the goals that somehow sustain us during difficult moments? The ability to speak out, call men to action, the necessity to evolve toward those ideals, to establish the hope which sustains us through the tension, despair, frustration and sacrifice demanded of a people working to regenerate their nation is as necessary as the engine of a motor car.

The driving force of idealistic beliefs, the language of persuasion, is the final link for no thought has meaning unrelated to action! This phenomena is as old as history - the ancient Greeks called it rhetoric.

> "To speak", wrote Professor Rosenstock-Huessy, "means more than be a scientist or a poet or a demagogue or a narrator. It means to insist on the essential unity of all these four types of language. They all are needed, they all interpret each other. It is nonsense to believe that the scientist or the historian or the politician or the poet alone can know the truth. The truth is in a man who can speak all four languages with sincerety - ... and who does not disrupt the unity of speech by running away into a merely scientific, a merely poetical, a merely petrified or a merely revolutionary language."

The above conviction suggests a triangular relationship and a meaningful interaction among the three components: Science, Human Values, and Technology.



Paul de Hurd aptly summarizes the above discussion:

Science provides knowledge. Technology provides application of that knowledge; and our value concepts guide what we ought to do with both.

Conclusion:

It is the writer's hope that the above discussion may serve to encourage all concerned to think, organize and strive further together towards helping students in developing countries to think, discover and contribute to scientific knowledge.

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GAMES, SIMULATIONS, AND ROLE-PLAY AS TEACHING STRATEGIES FOR STS: SCIENCE, TECHNOLOGY, AND SOCIETY

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Introduction.

In recent years, there have been more and more references in the literature concerning the use of games, simulations and role-play in education and particularly in science education. These literature references have included articles, science textbooks, commercial games, syllabus statements and even special journals and periodicals.

One might well wonder how games, simulations and role-play originated and arrived in education generally and in science education in particular, why they have been used, and what have been the outcomes. This paper attempts to answer these questions briefly and in particular to outline the advantages of using games, simulations and role-play in STS.

What are games, simulations and role-play ?

There are serious problems involved in this area when one searches for or attempts definitions of these three activities. Firstly, there is such a very great range of activities under these three headings of games , simulations and role-play; and secondly, many authors have taken such words as "game", "simulation" and "simulation game" to be the same. Add to this the even more recent advent of computer games and simulations and it is easy to comprehend the difficulty of definition. In practical terms, it is often best to take the meanings from the context of the author.

In my own case, I have the following operational definitions that I use in my teaching , and these definitions are the ones I will use in this paper. I tend to use the word "game" for such things as playing cards, hangman, crosswords, and simple board games, often used for revision purposes; by "simulation", including "simulation games", I mean such things as chess and monopoly, where strategy is involved, as well as such things as simulated excursions or health clinic; and by "role-play", I mean the playing out of a situation or topic where people play a role but there is no script, such as the Uranium debate or Random Breath Testing.

Where did games, simulations and role-play come from ?

Initially, games seem to have been played by people all over the world in all ages, with many games having originated from facets of everyday life. Perhaps games are simply an extension of play, and indeed this universality of games and play might suggest that games and simulations are a desirable, if not inevitable, vehicle for educators, since young people perhaps more than anybody are the inheritors of the game and play tradition.

However, the deliberate use of games and simulations in education as a strategy of teaching and learning rather than as entertainment or an addendum is relatively recent. Despite the idea that games and play could be of value in education going back as far as Plato, the recent use of games and simulations in schools did not spring from this theoretical source. Rather, the route taken by games and simulations into education seems to have been via war games of the military and then through business and politics into social science education. Then, from this social science background, games and simulations arrived in science education relatively recently, at least judging from the dates of production of commercially produced games, articles on games in science teaching journals and research articles on games.

Particularly for science education, one could surmise why games and simulations were not used earlier and what in the educational climate has enabled their use to be implemented. Perhaps the very fabric of science teaching did not lend itself to games and simulations earlier. That is, science teaching in the recent past seemed to have involved experimentation as a real, factual coverage of what scientists are and do and maybe this did not aid the advent of simulation techniques. But, with science syllabi changing to emphasise the more social aspects of science, it would seem reasonable that science teaching would be more receptive to games and simulations which had already arrived in the social sciences.

Alongside this tendency to more social aspects of science there has been the trend to an increase in the active participation of students in lessons. Again, this can be traced in syllabus statements of late, where teachers are encouraged or expected to emphasise such things as individualisation, use modern technology, give students other activities or experiences besides experiments, and generally change their role, particularly in a more "Process" approach to science rather than a "Content" approach. So, it is not hard to see why science teachers have become aware and more interested in such strategies as games and simulations, since these seem suited to the syllabus approaches.

What claims are made for games, simulations and role-play ?

In my survey of the research literature, I found numerous claims for games and simulations. But, as in other fields, the majority of claims were not borne out by the research findings. It is also worth pointing out that most of the claims and the research dealt, as one might expect, with the social sciences.

Bearing in mind these provisos, from all the surveys over the years, it was reasonable to state three generalisations with some confidence about this field of study. These were that, compared with traditional teaching methods, games and simulations were :- i) no better or worse in general student learning; ii) superior in increasing student motivation and interest; iii) still in doubt concerning changes in student attitudes .

However, alongside this simple summary, some underlying and important points should be made. Firstly, the range of games, simulations and role-plays is so wide that care must be taken in extending claims and findings to all of these activities; and secondly, a point stressed by many researchers and teachers, research in this area should be concentrated on finding what these activities especially do, rather than carrying out comparative work and trying to find out how games, simulations and role-plays compare to more traditional teaching methods.

My own research tends to support these findings. I have theorised that games, simulations and role-plays lie in the same area as practical work, in that the active nature of the exercise appeals to students. Further, I have theorised that games, simulations and role-plays, as an extension of the teacher variable, influence positively the classroom climate through active involvement of the students in an exercise involving group dynamics and this leads in turn to more popular lessons.

What can games, simulations and role-plays do for STS ?

I believe that there are several things that these activities can achieve for STS. Indeed, since these activities came from social science into science education, as outlined earlier in this paper, it seems reasonable that games, simulations and role-plays should sit quite comfortably with STS which stresses social issues.

At the outset, I would point out that a curriculum change of itself tends to make little or no difference in the attitudes of students towards science. Perhaps the best illustration of this is the P.S.S.C. Physics course in the U.S. where Physics enrolments dropped despite the new curriculum. I would contend that STS could have a similar negative effect on student attitudes, especially if STS were to be taught in a "traditional" way, with students largely in a passive mode. This, of course, is suggesting that teaching methods and strategies should be considered alongside any curriculum change.

So, I am suggesting that STS can gain in this way. It seems reasonable that a teacher of STS who uses a variety of teaching techniques, some of which could be games, simulations and role-play and other strategies to make students more active, will tend to create a lively, stimulating classroom climate which will be perceived by students as being more enjoyable. In this way, students will have a more positive attitude towards STS.

Another way that STS gains in this area of games and simulations is concerning the research. As pointed out earlier in this paper, most of the research on games and simulations has been done in the social sciences, and therefore most findings from research refer to social science education. By its very nature, STS has this social side to it and so the research done on games and simulations could be said to relate more to STS than it does to science education itself.

Syllabus changes can also relate STS to games and simulations. For example, in New South Wales recently we moved to an Aims-based, student-centred syllabus in science for years 7-10. Within the syllabus and the syllabus support documents it was clear that teachers were expected to use a variety of teaching methods and to make apparent the social relevance of science. Further, at a recent conference, organised by the N.S.W. Department of Education, the entire content section of the syllabus was easily cast into an STS framework, which while not being mandatory was intended to aid teachers in their syllabus application. It was evident that simulations and role-plays easily fitted into this STS framework as a vehicle for many of the teaching objectives, which involved many aspects of the quality of life.

Summary. Games, simulations and role-plays are interesting teaching strategies that have found use in social science education and more recently in science education. These strategies are claimed to promote student interest and motivation, perhaps because they involve active students, group dynamics, and a change in classroom climate and teacher role. These activities could be usefully employed in STS where student interest is desirable and where various teaching methods need to be adopted.

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a) The educational system of New South Wales, Australia.

In Australia, the Federal government is largely concerned with University and tertiary education. This leaves each of the States with responsibility for its own primary and secondary system. In the state of New South Wales, students begin school at Kindergarten year at age 5 and then move on to 1st year or Grade 1 through to Year 12. Students attend primary school until the end of Year 6 at about age 11, when they then enter High school. Students can leave the High school after Year 10, but can continue their studies into Year 12. At the end of Year 12, at about age 18, students sit public examinations called the Higher School Certificate and the results from this are used to determine university entrance.

b) My paper fits into the High school in the New South Wales system. That is, the paper fits into Years 7 - 10, where students study "Science" as a composite, compulsory subject, as well as into Years 11 and 12 where students choose to study the individual disciplines of Physics, Chemistry, Biology, and Geology or combined general Science courses.

c) A brief autobiographical note.

I hold the following degrees and diploma:-
Batchelor of Science (B.Sc.) in Chemistry ;
Diploma of Education (Dip.Ed) ;
Master of Education (M.Ed.);
Master of Science (M.Sc.) in Chemistry;
Master of Arts (Hons) (M.A. (Hons.)) in Education.

I began teaching in England, where I taught for 1 year before moving to Canada. I taught in High school in England, while I taught in both primary and junior High school in Canada. In Toronto, Ontario, I taught for 2 years before moving to Australia, where I have been ever since. I have now been teaching in High school in New South Wales for the past 17 years, being Head of Science in my present school for the past 9 years.

My publications include several articles in our local science teacher journals, as well as numerous inservice papers, books of test items, and teaching aids for the New South Wales Department of Education and the Science Teachers Association.

AN INSTRUCTIONAL STRATEGY FOR TEACHING SCIENCE & TECHNOLOGY: THE ACID RAIN PROBLEM

William E. Searles & Susan Van Putten (Canada)

A number of publications have recently come into being describing, in detail, a variety of teaching strategies that affect the traditional approach associated with science education. Such strategies are based on sound instructional theories, cater to the needs and interests of students and are relevant to teaching specific topics in particular environments. These different instructional viewpoints are extremely useful to science teachers who are receptive to new ideas and experiment with various teaching strategies. The purpose of this presentation is to describe an instructional strategy that was utilized in dealing with the topic of acid rain.

Group Investigation of Acid Rain

Acid Rain exists, its an environmental problem, let's get going and solve it, explained the newspaper clipping. One of my grade eight general science students had cut the article from the paper and drew it to my attention. As I read aloud the story to the class their comments varied from, "What's an acid?"; "The Americans are killing us"; to "Oh, its terrible, soon we'll have no water suitable for drinking". Although the students had heard of the term "acid rain", they were unfamiliar with its meaning; however they were curious and enthusiastic to learn about this serious environmental problem.

Our class investigation into acid rain parallels the model of teaching based on the theories of Herbert Thelen and John Dewey, called Group Investigation (Joyce & Weil, pp. 226-240). The teacher is not the source of information but provides a classroom environment that is compatible with the process of inquiry and works closely with the students as a counsellor and supervisor.

In our case, by analyzing the problem, the class decides on how to organize the investigation and gather information. Finally, students report their results, evaluate the solution and their progress. As more problems occur the cycle is repeated. To obtain a broad understanding of the acid rain problem each student agreed to read a pamphlet or article published by a government. A classroom discussion on the readings led us to identify four problem areas associated with the topic:

1. Source or Cause of Acid Rain.
2. Areas of North America Affected and Why?
3. Effect on the Environment: (a) aquatic, (b) agricultural, soils, crops and forests, (c) human health and man made structures.
4. American and Canadian responses. What is being done to prevent further environmental deterioration? This general reading and discussion provided an overall picture of the various aspects

of acid rain and its effects on the environment. It also helped the students decide on the particular area of the problem they wished to investigate.

Before breaking up into four groups we established a few class rules. Resource materials had to be shared, no cutting out of maps or pictures unless agreed to by all other groups. An oral presentation would be required by each group at the end of the investigation to share knowledge acquired. The highly scientific articles would be my responsibility, as they were too difficult for the students' comprehension. I would pass out any important data to the appropriate group. Where I would also obtain any materials or equipment required for group experiments. A ten day time limit was set for the preparation of the presentation by each group. The students then chose their own groups and began an investigation into their area of concern. The major findings of each group, now follow:

Group 1: Cause and Source of Acid Rain (What goes up must come down)

Acid rain is now the most serious pollutant in North America which is now experiencing its devastating effects. A more correct term to use is acidic precipitation as the pollutants fall to earth in two forms: Wet deposition: hail, sleet, rain, snow, and smog, and Dry deposition: the pollutants turn acidic after falling to earth by mixing with water. The term acid rain is used to describe both of these mechanisms. Clean rain has a pH value of 5.6 which is slightly acidic due to the reaction of carbon dioxide with water in the atmosphere. Acid rain has a pH value of less than 5.6 (Still Waters p.11 & National Geographic, p. 660) with the normal rainfall in the eastern regions of North America ranging from 4.5 - 4.0. (At this point, the group discussed the pH scale).

The sources of acid rain are sulphur dioxide (SO_2) and nitrogen oxides (NO_x) released into the atmosphere after man's industrial activities. The burning of fossil fuels, coal, oil and natural gas combined with the smelting of sulphur rich ores are the prime sources of sulphur oxides. Sulphur oxides create about two-thirds of the acid rain problem with nitrogen oxides the other third (Dotto, p. 38). The amount of gaseous sulphurous oxides emitted in North America in one year is approximately 31 million tonnes; 26 million tonnes are produced in the United States, 5 million in Canada. The group presented a graph illustrating the various sources of sulphurous oxides and compared the total emission in the U.S. and in Canada.

A second graph depicted emissions of nitrogen oxides, and illustrated that the oxides are by-products of exhausts from cars and other forms of transportation (46%), with the rest coming from coal fired power plants and furnaces (54%). The

U.S. produces 22 million tonnes of nitrogen oxides with Canada contributing 2 million tonnes, a 10:1 ratio (Choquette, p. 7). The oxides emitted go through a series of chemical changes as the winds carry them through the atmosphere. The group then displayed a map of North America with the major polluters listed according to their location and order of importance as a polluter. This was followed by the role of the tall smoke-stacks and how prevailing winds carried the pollutants hundreds and even thousands of kilometres from the producer.

Group 2: Areas of Canada and the United States Affected by Acid Rain

Several maps were exhibited that indicated those areas of the United States and Canada that were affected by acid rain including one indicating those regions of North America containing lakes sensitive to acidification (Still Waters, p.15). The maps illustrated the most seriously affected areas as being the New England-Adirondacks in the U.S. and Southern Ontario-Quebec, St. Lawrence River Valley of Canada. This map was then compared with another map that depicted the approximate pH values of rainfall across the continent (Downwind, p.7). A map showing the important summer and winter storm paths (Downwind, p.7) was then displayed to verify the information presented on the previously examined maps.

Acid Rain in Quebec and Ontario

In Quebec, the acidic precipitation ranges from pH 4.5 in the south to a pH of 5.5-6.0 in the north. Group 2 toured the island of Montreal sampling local waters with a pH testing kit. Their data indicated a pH level ranging from 4.3 to 4.6, clearly a threat to Montreal's quality of life.

Presently in Ontario 48,000 lakes are threatened with acidic pollution. The Sudbury area has recorded over 200 lakes too acidic to support any fish life.

Acid Rain in Canada's West

At present there is no evidence to show a serious problem existing in Canada's western provinces.

Buffering Capacity (Why some areas are not affected)

Some areas of North America have a natural resistance to acid rain for although acid rain falls, there appears to be no appreciable difference in the pH of the soil or water. These areas possess natural buffers that are capable of neutralizing the acids. When the natural buffers are exhausted the pH of the environment declines and becomes acidic. Alkaline salts, such as calcium carbonate are excellent buffers. The soil of Atlantic

Canada is poor in natural buffers and is highly susceptible to acidic precipitation. The Canadian Shield, in eastern Canada is composed mostly of granite, which has no neutralizing powers. In this respect, Ontario, Quebec, and New York State are constantly exposed to the acidic rainfall, and have no natural immunity. Water bodies that are alkaline also possess natural buffers. Lakes and streams surrounded by carbonate rich soils have this capacity (A diagram in National Geographic, p.670 was then used to illustrate this fact).

Group 3: Environmental Effects of Acid Rain

Not restricted to killing our lakes, the acids are damaging human health, man-made structures, wildlife, forests, soils, and agricultural crops. Due to the complicated action of the acids on the environment the group reviewed the literature, summarizing the effects as follows:

Aquatic and Wildlife Effects

As the pH decreases below 5.0, fishlife becomes seriously affected. Below 4.5 no fishlife exists. Hundreds of lakes in Ontario and the Adirondacks have already reached this point. The scenario that follows represents the decline in the aquatic environment: loss of micro-organisms (algae) resulting in declining numbers of small invertebrates (clams, mussels, snails, crayfish) and aquatic insects. Amphibians reproductive cycle is interrupted by the highly acidic spring runoff and the fish reproductive cycle is devastated, when even if the eggs hatch the fry are often deformed. Adult fish lose calcium from their bone tissue - resulting in such deformaties as hunchbacks. Aluminum (released from the soil, accumulates in the lakes) clogs the fish gills resulting in suffocation. Aquatic birds are in danger due to a dwindling supply of food. The food chain of the aquatic environment is seriously disrupted. A graphic illustration was presented that showed the effects of a decrease in pH on various freshwater organisms (National Geographic, p.660).

Agriculture, Forests and Soils

Of primary concern to scientists is the loss of nutrients from the soil for as the pH of rainfall declines, elements are leached from the soil depriving plants of essential nutrients. The sulphurous oxides settling on the thick layers of snow in most of northeastern North America acts as a potent dose of sulphuric acid when released in the spring runoff (Downwind, p.10). An example was provided of a lake that normally had a pH of 7 dropping to a pH of 5 when the spring runoff occurred. To determine the effects of acids on germinating seedlings the group conducted an experiment of their own design from which they reached the following conclusion: As pH becomes more acidic growth changes from normal and near normal, to none at all.

Human Health and Man-made Structures

Although there is no direct evidence linking acid rain to human diseases, scientists suspect that respiratory ailments, bronchitis, asthma, and emphysema are trouble areas. Another danger to human health is the quality of our drinking water.

Canada's Parliament buildings are also being affected by acid rain. The sandstone blocks and mortar holding them together are crumbling necessitating costly repairs (Silent Peril, p.1). The group presented numerous pictures from the literature to demonstrate the damage to architectural structures which in Canada and the United States, is roughly estimated at 3 billion dollars per year (Downwind, p.14).

Group 4: What's Being Done To Reduce the Quantity of Acid Rain?

COOPERATION is needed to solve this problem. Neither country, the United States or Canada is blameless. Industry has met (in part) government set emission standards, therefore they deny blame and are reluctant to spend the required finances. Scientists seek a total ban, or a severely reduced emission rate to prevent total destruction of the environment. The technology available to reduce the emissions of SO_2 in power plants was then described as was their efficiency and disposal of waste products. The Canadian non-ferrous smelters, such as, Inco's operation at Copper CLiff, ON, have reduced their emissions by installing a sulphuric acid plant. These plants retrieve some of the SO_2, but much is still released (Still waters, p.41). Sulphur rich coal can be "washed" prior to burning, reducing the emission of SO_2 by 10 to 40% (National Geographic, p.679).

The 48,000 lakes already suffering from the effects of acidification in Ontario, will cost from $4,000 to $40,000 per year, per lake, to treat with limestone. Obviously, "liming" is an emergency solution for certain lakes and streams to restore desirable fish populations (Still Waters, p.59).

Nitrogen oxide pollutants can be reduced significantly by placing stricter controls on automobile emissions. Canada, following the U.S. in these laws, to control exhaust gases is considering a yearly inspection for urban vehicles. Nitrogen oxides are expected to decline in the next decades as more fuel efficient cars are in operation (Still Waters, p.47). Drivers can help by using lead-free gasoline, keeping autos well tuned, and adopting smooth driving techniques, then NO_x emissions will be reduced.

The Americans are unco-operative in dealing with the acid rain problem. The last two presidents have stressed an energy self-sufficiency policy, so power plants are converting from burning foreign oil to American-mined coal. Emissions of SO_2 are therefore increasing, with many of the major polluters exceeding the emission standards (Still Waters, p. 35). The U.S. Environmental Protection Agency (EPA) has unfortunately increased the acceptable emission standards, much to Canada's disgust. Five Canadian provinces have adopted laws to strictly enforce emission standards, but many citizens consider that it is illogical to take such stringent measures to curb air pollution as much of our acid rain problems originate south of the border.

Group 4 contacted several federal and provincial members of parliament to assess their knowledge of acid rain and the government's responsibility in stopping the pollutants. Most politicians were willing to talk to the students and were rated according to their knowledge of the acid rain problem, as well as their efforts to bring about an acceptable solution.

In summation neither government, federal or provincial, appears willing to drastically reduce the emissions of SO_2 and NO_x. Antipollution laws are passed, but time limits are relaxed due to the high cost of abatement procedures. The Canadian government is more concerned than the American government, but acid rain does not appear to be a high priority item.

General Conclusions

Thelen's model of group investigation stresses that education is not just a school responsibility, but a community one (Thelen, p.10). Our investigation on acid rain bridged this gap.

The benefits derived from our inquiry are many: That scientific knowledge was obtained is important but improvements were also seen in the areas of reading, thinking, writing, and in articulating findings for acid rain. These nurturant effects occur as a result of participating in the investigation. Other benefits from group investigation can be summarized as:

1. Total student involvement in the learning process

2. Personal meaning to knowledge

3. Heightens self-awareness

4. Independent learning translates into meaningful learning and knowledge.

My role throughout the group investigation was one of a facilitator. Like my students I gained scientific knowledge on the acid rain problem, but more important I came to know each of my students as individuals. My "free time" was spent counselling the groups, helping them understand the readings, and arranging the information to be presented.

In the examination of real-life scientific technology issues, the goal is for teachers to use a multi-disciplinary approach. No one text is sufficient to meet these needs. What is required is the use of community resources and a willingness to co-operate between teachers and students. "Life is a social process of inquiry, seeking to establish a way of life in which all can participate, and through which each may achieve self-realization " (Thelen, pp.158-159). We achieved these goals.

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Quebec's pre-university educational system has two divisions French and English. Elementary School,

Grades K	1 - 6	ages 4-11
High School	Grades 7-11, ages 12-15/16	
C.E.G.E.P. college	Grades 12-13, ages 16 - Adult.	

Dr. W.E. Searles, Professor, McGill University, 1965 - present. Responsible for graduate studies in science education with particular interests in science & technology, instructional theories, and student thinking in laboratory investigations.

Susan Van Putten, High school biology teacher and a graduate student in science curriculum studies.

A METHOD FOR TEACHING SCIENCE, TECHNOLOGY AND SOCIETY ISSUES IN INTRODUCTORY HIGH SCHOOL AND COLLEGE CHEMISTRY CLASSES

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Information in news reports is often about "chemically" related problems and issues of personal and, at times, global concern. Examples include nutrition and diet information, drug abuse, pollution of the environment, nuclear radiation, ozone depletion, toxic waste disposal, etc. To deal with such problems and issues in any realistic manner in the classroom, broad societal concerns e.g., scientific, economic, social, political, religious, ethical, etc., must be taken into consideration.

Recognizing the importance of this type of reflective and critical thinking, a number of state and national groups have encouraged the following goals for the high school curriculum. These goals, which also have implications for chemistry at the college level, include: "to prepare students to use science and technology in understanding and improving [students'] daily lives" [1], "to apply scientific knowledge to everyday life; and to introduce social and environmental implications of scientific and technological development" [2], "to use current societal issues and problems to meet the needs of our society and of students" [3], "to emphasize at all levels the social and human relevance of chemistry" [4], "to use attitudes and knowledge about science to live as an informed citizen in a scientifically developed nation" [5], etc.

Problem

Texts provide few, if any, systematic procedures for involving students with societal problems and issues in their lives that are related to chemistry. An exception for high schools is "Chemistry in the Community" [CHEM--COM], developed by the American Chemical Society. High school chemistry teachers generally are reluctant to discuss issues to any extent in class because the time that is required is at the expense of the regular subject matter [6]. Approximately 90% of all high school science teachers emphasize goals directed toward preparing students for a major in a science in college [7]. And, issues in science and society generally are not included in first--year college chemistry [8].

Solution: Student Projects For Extra Credit

To operationalize the goals above, I have devised a method in my introductory, general education chemistry class which can also be applied in high school chemistry. Students are provided with a list of suggested issues from which they may select one as a project. Their task is to resolve the issue by means of a debate that is presented on paper. Examples are: "Should nuclear power plants continue to be developed for domestic energy sources?" "Should public smoking be banned?" "Should all food additives be banned?" "Should steroids be made available to athletes?" "Should diet promotions be restricted?" Students are encouraged to choose issues of personal interest to them.

The method, outlined below, requires no class time since it is for extra credit. Instructors have however, the flexibility to assign one or more of the issues for actual student debates in class. The project is divided into seven parts, A to G, which may be selected in any number for completion. The only stipulation is that students begin with Part A and that the first three are in sequence. Each part is scored separately and worth five or 10 points depending on its difficulty. Grading time is relatively minimal since the work handed in can be scanned quickly due to the structured way in which it is presented. This includes a heading with the student's name, the issue in question and the PRO or CON position taken. The write--up is completed and graded under the specified directions supplied to students in handouts. For a detailed copy of the handouts please correspond with the author.

The Student Project

The following is a brief description of how the project is presented to the students in class for extra credit.

Part A (5 points): Issues Introduction

Select an issue, indicate whether you are PRO or CON, then list (by enumerating) the reasons for your choice. Your reasons should be carefully thought out but do not need to involve any research at this time.

Part B (10 points): Chemical Background Information

Xerox a minimum of five articles (or more if needed) with chemical information on your issue. Your sources of articles should be from scientific journals such as Chemical & Engineering News, Science Digest, Popular Science, Discover, Science 80 to 86, Journal of Chemical Education, etc. Use the Education Index, Readers' Guide to Periodical Literature, Los Angeles Times Index, New York Times Index, for other sources of information. Underline all of the scientific information in the articles pertaining to your issue, then staple the articles to a one to two page summary of the chemical information on the issue in the articles.

Part C (10 points): Debating the Opposite of the Issue

Prepare to debate the issue in one to two pages from the opposite viewpoint that you took in Part A. That is, if you first indicated you were PRO on the issue, you will now debate CON on the issue. Prepare your debate by looking at a wide variety of perspectives on the issue such as scientific, economic, social, political, religious, ethical aspects, etc. Enumerate each point you wish to make in the debate, then indicate in parenthesis at the end of each statement the basis upon which it was made. Use (sci) for scientific, (eco) for economic, (soc) for social, etc. Remember that you are debating the OPPOSITE position from the one originally taken.

Part D (10 points): Personal Interview

Conduct an interview on the issue with a person who uses chemistry in his or her profession and who is not a member of the faculty or a family member. Prepare questions you plan to ask prior to the interview in order not to waste time. The questions should be first about the person's job, i.e., its connection to chemistry and then about the person's position on the issue in question. Staple your notes, the person's name, job, time, date and place of the interview to the summary of your interview.

Part E (10 points): A Survey on the Issue

Design an experiment involving a minimum of 40 people concerning their position, PRO or CON, on the issue. To do this, you will need to compare two groups of people (experimental variable) such as college versus noncollege, upper division versus lower division students, etc. and reasons why you chose this comparison. Before beginning, state your hypothesis predicting a relationship between groups of people (the experimental variable) and whether their position is PRO or CON (the dependent or outcome variable). For example: It is hypothesized that lower division students are more likely to be PRO on the stated issue than upper division students. Or, there is no significant difference of the percentage of males who are CON on this issue compared to the percentage of females who are CON the same issue. Collect reasons from the respondents why they decided to be PRO or CON on the issue. Specifically, was their PRO or CON choice based on economic, social, religious, scientific, ethical, political, moral, etc. reasons. Staple together data tables, graphs, summary, conclusion and explanation of the results. (Students are given a sample questionnaire that could be used in the collection of data.)

Part F (5 points): Summary of the Issue

Based on all of your work in the project, indicate what your position is now on the issue and support this position by listing your reasons. Elaborate on each reason by means of a few short statements or a paragraph. Indicate also on what perspective each of your reasons is based, i.e., scientific, social, economic, political, religious, ethical, etc., considerations.

Part G (5 points): Recommendations for Further Study on the Issue

Consider all of the information aquired in the project on the issue, then recommend at least ten sub--issues for further study. Each of the sub--issues is a refinement on the issue that could be studied by a classmate in the future.

Project Benefits

Involvement in projects allows students to view chemistry and problems in society and in their lives from broader, interrelated and more personalized perspectives. They must think extensively and critically on topics and practice important writing skills to present their views. Also provided are opportunities to design an experiment using "scientific methods" procedures and to examine chemistry related careers through personal interviews.

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Pre--University Education in California, U.S.A.

Elementary grades are kindergarten (age 5) to grade 6 (age 11) or to grade 8 (age 13). Junior high school is grade 7 and 8. Some school districts prefer the middle school for grades 6 to 8. High school is for grades 9 to 12 (ages 14 to 17 or 18). Community college is generally available to adults in a vocational or an academic component. The academic component is equivalent to the first two years of the university curriculum. Entrance to the academic component of community colleges and the university is determined by completion of recommended high school courses and examinations.

Manuscript Application

The manuscript has applicability in science courses in high school and in introductory science courses in community colleges and in the university.

Autobiographical Note

Dr. H. Eric Streitberger is Professor of Science Education, Chemistry and Teacher Education and the Chair of the Science Education Program at California State University, Fullerton, California. His B.A. degree is in chemistry from the University of Northern Iowa; the Ph.D. is in science education from Oregon State University. Teaching experience includes high school science in the State of Iowa and in American schools in Germany; university undergraduate and graduate science education classes and introductory chemistry lecture and laboratory. He has published in educational journals and directed a number of National Science Foundation sponsored teacher in--service institutes. He is co--author of "Fundamental Physical Science Activities for the Middle Grades" with G. Carlson, Calif. State Univ., Fullerton and "Introductory Armchair Chemistry: A Learn By Doing Text" with H.N. Alyea, Princeton University.

STUDENT RESPONSE TO TECHNOLOGICAL INNOVATIONS IN A SCIENCE METHODS COURSE

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Introduction

SODIA-Science is the science component of the SODIA Elementary Teacher Preparation Program at Utah State University. The acronym SODIA is derived from the initial letters of descriptive words (Self, Others, Disciplines, Implementation, and Associate Teaching), which represent the emphasis that is placed at each level of the program. The SODIA program was cited for special recognition for excellence in teacher education at the 1974 annual meeting of the American Association of Colleges for Teacher Education. SODIA-Science was one of seven programs recognized in the 1985 National Science Teachers Association-Search for Excellence in Science-Preservice Elementary Teacher Preparation Program. The seven 1985 award winners met all NSTA standards for excellence.

In 1985 SODIA-Science received a three-year U.S. Department of Education grant under the "Synthesis and Use of Research in Education" project. The purpose of this funding was to identify and document research-based approaches to improvement of teacher education.

Technology Related Innovative Course Components

Pretesting

The SODIA-Science program was modified in 1984 to accommodate concerns about science content background (Beryyessa, 1959; Lamors, 1949; Lerrer, 1957; Rutledge, 1957; Wishart, 1961; DeRose, 1979; Fitch, 1979), science process skills (Blosser, 1969; McDermott, 1976; Rowe, 1978, Suchman 1976; Victor, 1974), and match between science topics taught to teachers and topics taught to children (AAAS, 1970). Modifications included requiring all students in the Elementary Teacher Preparation Program to take Biology 101 (5 credits), Chemistry 101 (5 credits), Geology 101 (5 credits), and Physics 120 (5 credits) as prerequisites to a five credit science methods course, EL ED 401. All students registering for EL ED 401 must take a pretest to demonstrate scientific literacy. The pretest includes a content subtest with Life, Earth/Space, and Physical Science sections; a Science Process Skills subtest; and an Attitude Toward Science subtest. The instrument was modeled after the 1982 British Columbia Science Assessment (Taylor, 1982). Students scoring lower than 80% on any subtest must follow alternative remediation strategies.

The pretest is contained on Apple IIe compatible diskettes. Students check out the pretest diskette from a media center and are assigned an Apple IIe computer with printer. The diskette envelope includes printed start-up instructions. Upon completion of the exam, students follow diskette instructions to obtain a performance printout. The printout includes an item by item performance record, a profile of performance for each of the subtests, and an outline for suggested remediation. The printout is shared with the instructor for counseling purposes. This process must be completed the first week of the term. Student response to the pretest, as reported on the 1986 Fall Term course evaluation form, is summarized as follows:

PRETEST	😄	🙂	😐	🙁	😟
Manner of administration	35%	30%	22%	11%	2%
Feelings about knowing your competencies	33%	35%	17%	15%	0%
Procedure for informing of test results	46%	20%	27%	5%	2%
Counseling process	50%	18%	20%	10%	2%

Content Remediation

Content remediation may consist of auditing a content course, retaking a content course, following a video-study guide procedure, or devising an individualized remediation plan. To date, all students requiring content remediation have elected to use the video-study guide option. Study guides are available for life science, earth/space science, and physical science (Insights, 1986). The video cassettes are keyed to accompanying study guides that are not only content relevant, but also elementary school grade level appropriate. Every quarter a few students find it frustrating to devote the extra time needed for remediation. Students failing any part of the pretest are informed that they have up to three quarters (9 months) to complete remediation requirements. These students perceive their entire time schedule for completion of their program falling apart. The initial response is panic. To date, their concerns have proven to be unfounded, as all students have completed remediation within the term they registered for the science methods course. Once resigned to the fact that they must pass a retest at the 80% competency level before completing the science methods course, all take the process very seriously.

The two major assets of the video cassette approach are cost and student familiarity with the technology. All students have used VCRs at home or in classroom settings. The technology is no threat to our students.

Video cassettes are housed in a media center. They are checked out on a four hour or overnight basis. Most students view them at home. Occasionally small groups of students view the cassettes on media center equipment. Student time devoted to remediation for a given content area has ranged from a low of four hours to a high of 32 hours. These times include viewing, use of the study guide, and in some cases counseling with the instructor prior to retesting.

Retesting is conducted in the same procedure used for pretesting. Tests are contained on Apple IIe compatible diskettes. When ready for a retest, students request the appropriate diskette from the media specialist and are assigned to a computer with a printer. After testing, students present test results to the instructor for approval and/or counseling. No student has required more than two retests.

Students completing the content remediation process rated the experience highly. Less than 2% of students requiring remediation ranked the process negatively on course evaluation forms. Upon completion, students have a general sense of competence and assurance that they can teach science. The change in attitude from pretest to completion of remediation is very positive.

By midterm, many students that passed the pretest have had positive feedback from students using the remediation video cassettes. About 10% of the students passing the pretest fall term 1986 requested and used the content remediation cassettes on their own.

Computer-mediated videodiscs were also considered as a means of achieving remediation. Equipment and videodiscs (Hofmeister, 1985) are available at the elementary laboratory school media center. Students are introduced to this technology in the science methods course. Student feedback indicated that no students used the technology after the demonstration. This response, plus the high cost of programs ($1200 vs. $200 for videocassettes) resulted in the decision not to use this technology for science content remediation.

Process Skill Remediation

Students requiring remediation in the science process skills are counseled to follow one or more procedures. All are counseled to attend a three-hour instructor-directed review of process skills. The review is open to all students. Skill weaknesses identified in the pretest are also keyed to specific activities in Sciencing (Caine and Evans, 1984) and in Stepping Into Successful Science Teaching (Lewis, 1986). The latter reference also includes a video cassette, "Introducing the Science Process Skills." Students are counseled to use these as they desire. Science process skills items are included on both a midterm and final exam.

Student response to the science process skill remediation was generally positive. The video cassettes were heavily used.

Science, Technology, and Society Component

Approximately 2/5 of the science methods course is devoted to a science, technology, and society component. This component was designed in response to findings summarized by Piel (1981). He concluded that as our society has become more technologically oriented, the science curriculum has become less so.

Although this component may not involve student use of technology in teaching, it is reported in this paper because it reflects a general concern that implications of technology be a major part of elementary teacher preparation. Students are introduced to science, technology, and society concepts in two 1-1/2 hour class sessions. Then students are assigned to science professors in groups of five for six more 1-1/2 hour sessions in which they investigate some aspect of science that has technological and social implications.

Response from students has been very favorable, but expense in terms of faculty time has been an area of concern. Issues related to faculty load and appropriate student activities have not been totally resolved.

Computer-Mediated Curriculum

Students receive approximately 110 hours of formal coursework in computer literacy prior to exposure to the practical aspects included in the science methods course. This background is achieved in two required courses that deal with a variety of hardware and software applications and their use in educational settings.

Another methods course innovation is based upon the Utah Core Curriculum. This document consists of a hierarchical arrangement of standards and objectives that must be achieved in Utah public schools. A computer-mediated resource file, the *Science Resource Guide*, has been developed (Daugs, 1985) to accompany the elementary science part of the Utah Core Curriculum. The computer file includes lesson plans, references to elementary science textbook series, resources for gifted and talented students, and ties to other subject matter areas at the same grade level.

The computer-mediated resource guide serves as a resource for students in their practicum. The practicum consists of a half day in an elementary grade level classroom. A cooperating teacher assigns each practicum student to teach some science. Assignments are made by State Core Curriculum standard and objective numbers. Students use core standard and objective numbers to find the required resources on the computer menu.

The *Science Resource Guide* is a sub-part of Project TIN:MAN (Technology Infusion Network: Management, Administration, and Novel Instruction). The primary goal of this project was to develop, implement, and evaluate a total school program utilizing the latest in computer information technologies for the purposes of enhancing student learning, teacher instruction and class management.

The Technology Infusion Network consists of a network of Apple microcomputers located in all classrooms and in a computer center at Edith Bowen Laboratory School, a grade K-5 elementary school located on the Utah State University campus. All computers are accessed to information and programs housed on a Corvus hard disk system (Corvus, 1984). Computers can be operated within the Corvus system or independently through the use of floppy disks.

In addition to exposure to the *Science Resource Guide*, practicum experiences include exposure to the management component of the Corvus system. This includes attendance records, grades, school lunch data, and item banks. The administration component further offers access to Appleworks word processor, data base, spread sheet, and the Science Core Curriculum. Novel instruction includes software in reading, mathematics, spelling, English, social studies, science, art, music, and alphabet.

Data collected by Findley (1986) were summarized with respect to Edith Bowen Laboratory School teacher response to Project TIN:MAN. It was concluded that the system is a "good" computer mediated instruction approach. This researcher infers that Edith Bowen Laboratory School teacher response is a critical factor in science methods class student response to TIN:MAN in total, and specifically with respect to the *Science Resource Guide*.

Fall term 1986, all students in their Edith Bowen Laboratory School practicum reported using the management system and the Science Resource Guide if the Edith Bowen Laboratory School teacher to which they were assigned used the system. Fifteen students were assigned to three teachers not using the system. None of these students used the management component and only seven of the fifteen used the Science Resource Guide. About half of the students used some of the software resources.

Student course evaluations of the Science Resource Guide, specifically, and TIN:MAN in general, are very positive. Items are included on a mid-term exam related to use of this technology. Fall term 1986, only one student in a group of 51 was not able to describe the system and how to use it. This was the same student that had the very negative response to the pretest, as reported earlier in this paper.

Further Research and Documentation

The 1986-87 school year was the first year of full program implementation. Feedback has been largely qualitative. Initial data indicate ongoing anxiety for science and the pretest. However, it is felt that this anxiety is largely alleviated by the end of the course. Student evaluations have documented this change. Initial plans are underway to further document anxiety alleviation by measuring physiological responses of the students in a variety of settings. One experiment will measure responses in a computer mediated pretest situation vs. responses in a paper and pencil situation. Another experiment will measure response shifts from pretest to final exam. The resulting physiological response data, complementing student evaluations, should document anxiety shifts.

The negative response to use of the computer mediated videodisc needs further investigation.

Long term effects of exposure to, and use of, project TIN:MAN components need to be investigated. At present, nineteen school districts in Utah have made the Science Resource Guide available to their teachers. Response has been variable. Follow-up studies need to document the use of the technologies during student teaching and after college graduation.

Educational System Information

The pre-university educational system in Utah is set up on a elementary school (K-6), junior high school (7-9), and high school)10-12) or an elementary school (K-5), middle school (6-8), high school (9-12) system, with entry at age five. Utah State University has an admission policy based upon demonstrated competence determined by a formula based upon combined scores in the English, mathematics, natural science, and social science sections of the American College Test (ACT) and the high school grades earned in the same subject areas. Mean ACT score for students entering Utah State University is 20.3 and for the subgroup entering elementary education is 19.1. Students in the course discussed in this paper are usually in their third year of university level education.

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Brief Biographical Data

Dr. Donald R. Daugs is course instructor for the science education methods course. SODIA-Science is one of the few in the United States that include an STS component for elementary teachers.

Dr. Daugs received his Ph.D. at Oregon State University in 1970. He was instrumental in developing a masters degree program in Environmental Studies at the University of Victoria. Since 1977, he has been the elementary science education specialist at Utah State University. He is presently President-Elect for the Utah State Science Teachers Association and is on the Preschool-Elementary Committee of the National Science Teachers Association. He is acting Director of the International Office for Water Education.

Recent publications include:

Daugs, Donald R. Comments on "The Importance of Terminology in Teaching K-12 Science," Journal of Research in Science Teaching, Vol. 21, No. 9, pp. 957-959, 1984.

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UNDERGRADUATE SCIENCE STUDENTS' CONCEPTIONS OF TECHNOLOGY: A RESEARCH REPORT

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INTRODUCTION

This paper discusses undergraduatae chemistry students' views on the nature of technology in the light of our theoretical understanding of the nature of technology and its interactions with society. The student views were examined using a variation of the Views on Science, Technology, and Society instrument [VOSTS CDN-2] (Aikenhead, Fleming, & Ryan, 1987) as well as interviews with selected students. The theoretical perspective used here is the result of an intense perusal of the literature from the philosophy and sociology of technology which has culminated in the monograph Technological Literacy (Fleming, 1987b).

BACKGROUND

Given the excellent collection of studies concerning the functioning of science,[1] it is interesting to note that few if any comparable studies have been done concerning the functioning of technology. Given the recent "boom" in articles and books dealing with the nature of technology (Bugliarello, 1986; Jonas, 1984; Kline, 1985; MacKenzie & Wajcman, 1985; Norman, 1981), it was of interest to this researcher to examine the normative beliefs about technology that are formed during the undergraduate science education experience. Little is known about the beliefs held both by prospective scientists and those who, though studying science, have other occupational plans. In Canada, prospective science teachers are drawn from both groups. Given both a national (Science Council of Canada, 1984) and provincial (Fleming, 1987b) interest in "the T in STS", knowledge about the beliefs about technology held by both these groups should prove invaluable both in the design of STS curricula which these people would implement and the re-design of teacher education programs.

There are data concerning the beliefs about technology and its social interactions held by graduating Canadian high school seniors (Aikenhead, Fleming, & Ryan, 1985, 1987). If it should turn out that there are no significant differences in views on technology held by graduating high seniors and undergraduate science students, it would mean that many of the misconceptions held by those seniors (Fleming, 1987a) will remain part of the repertoire of future science teachers.

RESEARCH DESIGN

A sample of two hundred students was drawn from classes in the undergraduate chemistry program. Given the paucity of numbers in the third and fourth year courses (nine and seven students respectively), all these students were used. Of the remaining 184 students, 60 were second year students and 124 were first year students.

Based on demographic data supplied by the students, 25% of them listed their occupational goal as "physical or biological scientist." Six percent listed their occupational goal as "physician." The remaining forty percent had occupational goals such as "pharmacist", "home economist", "farmer", "interior designer", "agricultural representative", and "entrepreneur".

The researcher met these students during their first laboratory session of the year. During this time, all students were requested to write argumentative responses to four pairs of statements from VOSTS CDN-2. Thus, 800 "pair responses" were obtained. Given that twenty pairs of statements from VOSTS CDN-2 were used, 40 students responded to each statement pair. The number of responses should allow for theoretical saturation (Glaser & Strauss, 1967). The responses to the statement pairs were analyzed using the method described by Aikenhead, Fleming, & Ryan (1985, 1986).

The analyses of these student responses were used to prepare questions dealing with the interaction of science, technology, and society. These questions were posed during semi-structured interviews with a stratified random sample of 30 students. The responses of the interviewed students were transcribed and analyzed using methods described by Fleming (1986) and Goetz & LeCompte (1984).

RESULTS

All the results will be presented in the context of the monograph Technological Literacy (Fleming, 1987b) mentioned earlier. The major themes from this monograph that will be used in the discussion of the current research findings are: A meaning for technology, the relationship between science and technology, research & development (R&D), and technology & social change. Given present space restrictions, the ten data tables which present the results of the analyses of student responses to VOSTS CDN-2 are not included.[2] Rather, a summary of these responses is presented and examined in the light of the themes described above.

A meaning for technology.

Simply put, undergraduates studying science do not know what technology is. They equate technology with the production of artifacts, particularly those artifacts created by engineers. From a theoretical perspective presented by Pacey (1983), these students have a narrow view of technology which focuses not only on its products but also on its "know-how". They do not perceive technology as having an organizaional component (the administration of technology policy, the needs of unions and consumers of technology) or a cultural component (issues of ideology such as progress, habits of thinking in technical issues, ethical codes).

The relationship between science and technology

When specifically asked to do so, students differentiate between the roles of science and technology. In such cases, 75% of students see their roles as interdependent. This would fit very nicely with a model proposed by Barnes & Edge (1982). However, in all those cases where such a role differentiation would have been useful, it was not made. Science and technology were seen as having a unified role, labelled *technoscience* (Fleming, 1987a). The most common role ascribed to this enterprise was that of finding cures for diseases. It appears that students do not know that technology has *its own* cultural resources. In most cases, technology was seen as *subservient* to science, passively awaiting a scientific discovery it could apply.

Another implication of the technoscience perspective is that it appears that for approximately 50% of students, science must serve utilitarian goals. According to Ziman (1984), this instrument (R&D), in the hands of society, could be used to cure a number of social ills. It does not seem that science *in its pure or academic form* was ever envisioned as such a tool. Nevertheless, half the students interviewed believed in a social utility perspective on science. This was reflected in their belief the research funding should be based on potential social utility. In other words, all scientific research should lead to some development which would better our society.

Technology and social change

Technology's mandate is to change the very society in which it operates. This social change means that technology prompts a redistribution of status and power in the society. Over half the students in this study believed that the social changes wrought by technology resulted in social problems such as unemployment and crime. The computer was singled out as the major causative factor.

Interestingly, a comparable number of students adopted the technocratic position that scientists and engineers, by virtue of their training and knowledge base, had the expertise to decide the direction of technologically-based social change. Taking the optimistic view, the other half of the students adopted the democratic perspective that the people should have control over such social changes. A middle ground has been suggested by Habermas (1971). He asserts that we live in a decisionistic society in which technical experts are on tap but not on top. Without further probling interviews, it is not known whether students might favor this perspective over a more technocratic one. Nevertheless, it seems obvious that most students do not understand the nature of technological decision making in contemporary democracies.

IMPLICATIONS

Undergraduate science students, regardless of their career paths, are indistinguishable from high school graduates when discussing the interactions of technology with society. One might infer from this that pre-service teachers in science and STS education are woefully misinformed about contemporary ideas wish these misconceptions to be communicated to our students, schools of education and teacher training institutes must undertake the task of having students examine their misconceptions. Without this examination, STS education may collapse when confronted by the mis-education of its proposed practitioners.

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[1] A number of studies examine scientific work in its natural setting (Latour & Woolgar, 1979; Knorr-Cetina, 1981; Lynch, 1985). Other studies focus on scientific communication, particularly speech acts and written research articles. The former has been formalized as a study of scientific discourse (Mulkay & Gilbert, 1984). The latter is often referred to as "the organization of persuasion through literary inscription" (Latour & Woolgar, 1979, p. 88). These studies, as well as those dealing with the practical reasoning of scientists (Law & Williams, 1982; Lynch, 1985), have offered significant insight into scienific practice.

[2] These data tables, as well as a detailed discussion of their significance, are available from the author.

SCIENCE; TECHNOLOGY AND SOCIETY EDUCATION - PROGRESS, NEW TEACHERS' PERCEPTIONS AND PROSPECTS

A.J. Jennings (England)

In his book *Teaching and Learning about Science and Technology*, published in 1980, Professor Ziman suggested that it takes about twenty years for an innovation to penetrate the English educational system. Over the previous ten years, he claims, advocates of STS education have begun to win the curriculum arguments but that the principles have yet to be translated into action. Now, well into the second decade of this twenty year span, there are encouraging signs in terms of curriculum changes in schools and in public disposition towards science education. The question remains as to whether new science teachers are any better prepared for the task than their predecessors?

Curriculum change

For the new General Certificate of Secondary Education to be taken at the end of compulsory schooling there has been established a series of national criteria (DES, 1985). There are general criteria which apply to all subjects plus further criteria for all science courses and more specific criteria for courses in biology, chemistry and physics. While these criteria do not specify a national syllabus they do ensure that there is a core of material which will be taught to all pupils following a particular subject to examination level, regardless of the particular regional examination board syllabus being studied. Most significantly for our purposes, the science criteria require that all science schemes provide for pupils to gain knowledge and understanding of scientific and technological applications with their social, economic and environmental implications.

Additional encouragement in this direction has been given by a major Government statement on science education policy. After national consultations, the Department of Education and Science published in 1985 *Science 5-16: a statement of policy*. To many educationalists the policy objectives are not only acceptable but desirable. Many of them are highly relevant to the theme of this conference. Renewed and powerful emphasis is given to the achievement of a broad, balanced science education for all pupils. This could mark a radical departure from traditional early specialisation with its tacit encouragement to girls to opt out of the study of physical sciences. Broad, balanced science is already being exemplified in numerous GCSE examination courses leading to double certification in science rather than separate examination qualifications in biology, chemistry and physics. While it is too early to predict whether study of separate sciences to 16+ is generally to be replaced by various forms of modular or integrated science courses other policy goals herald additional changes.

Science education is to become more related to the world into which young people are growing up. Practical problem solving is to be an essential ingredient of a science education which is to show science interacting with industry, commerce and family life. In other words, our science education should move from its established emphasis on pure science towards generating an awareness in the next generation of the nature of science, its creative, imaginative and cultural richness, together with its mutual interation with technology and the profound social effects and choices which scientific and technological advance provide.

Public understanding

To educators committed to science, technology and society education these policy objectives will seem far from original. Yet, while these movements have been taking place in the school system, scientific matters have forced themselves into public consciousness through media attention given to in-vitro fertilisation, the spread of AIDS and the nuclear accident at Chernobyl. The ability of citizens in a democracy to engage responsibly in personal and public decision-making on issues which require some scientific understanding has become a matter of concern. An ad hoc group of The Royal Society (1985) has published a report entitled 'The Public Understanding of Science'. In the 1986 Bernal Lecture, Sir Walter Bodmer, chairman of the Royal Society group deplored the narrowness of British education which leaves many people with virtually no understanding of science. Science education, he said, "should include a discussion of the social roles of science and its involvement in everyday life" and he added "understanding risks, probability and the notion of variability is an important part of science". Lord Marshall, FRS, chairman of the Central Electricity Generating Board and 1987 President of The Association for Science Education has joined the call for STS education. He claims that his campaign to educate people about the risks involved in the use of nuclear energy would be much easier if the public had a better understanding of science. His lecture and booklet Your Radioactive Garden (1986) intended to restore confidence in nuclear power and government sponsored leaflets delivered to every home spelling out the facts about AIDS are examples of urgent attempts to inform the adult population. More significant for our purpose is the support now being given by establishment figures in the Royal Society and industry for science education in schools which has strong STS perspectives. Yet both the speakers mentioned also found it necessary to express cautionary words about the need for a good supply of quality science teachers who have appropriate qualifications and training. This is not a new problem. Professor J A Lauwerys, who began his eminent career at the London Institute of Education as a lecturer in science education, wrote forty years ago

> What everybody says we need in schools are science graduates who have been trained in scientific ways of thinking, who have a good knowledge of the social applications of science and who are interested in its history and philosophy. What we get are persons who have been forced to purchase a specific acquaintance with recent researches at the cost of basic training and who have studied the advanced parts of their subject in an elementary way, instead of the elementary parts in an advanced way. They should have a broad and cultural education, fitting them to become guides for the young. They get, instead, a narrow and specialised training......

Professor K Keohane indicated in 1974 that the situation has changed little.

> ...graduate scientists, who generally speaking are of high quality in their specialist scientific experience but whose university training may have placed them at a disadvantage from the point of view of teaching across the breadth of integrated science. Furthermore, their experience has seldom and regretfully placed much emphasis on the applications and implications of science.

Perceptions of science teacher recruits

The author has sought to discover whether science graduates of the 1980's are any better equipped for the new directions and objectives for science education. As one part of the selection process for science students wishing to take the postgraduate certificate of education at the London Institute of Education, candidates are engaged in a discussion on the nature of science and technology (Jennings, 1984). Many undergraduates in their final year still betray the weaknesses identified by Lauwerys and Keohane. Those applicants who have already undertaken postgraduate research or have worked in a scientific industrial field bring an altogether broader and more enlightened understanding to the nature of science. Many final year undergraduates, however, struggle with the meaning of phrases such as 'objective knowledge' and the 'subjectivity of the scientist' and reveal ambiguity in their speech about the way they use such terms as 'fact', 'theory' and 'law'. While a small minority have studied some history and philosophy of science, an equal number will talk naively of 'proving an hypothesis'.

To explore further their understandings of science, technology and of the science education to which they aspire a series of written questions has been used to sample opinion and this survey has confirmed impressions gained during selection discussions.

Of sixty science graduates surveyed there is general consensus that science comprises knowledge and methods, is concerned with discovering explanations of the natural world and develops organised systems of relationship. Many students are sympathetic to the view that science involves imaginative, controlled curiosity but there is no unanimity as to whether biology, chemistry and physics are man-made constructions. 20% of these teacher training applicants consider that the methods of science are neither elusive nor difficult for the layman to grasp and the same proportion think that science works to a set of values which are objective, value-free and aseptic! The predictive power and rationality of the theoretical representations of the natural world which science generates is not esteemed as important by 30% of the graduates sampled and while Ziman asserts that the intellectual demands of science are severe, this view is endorsed by only 30% of these would-be teachers.

Not surprisingly their notions of technology were much less refined than their understanding of science. Most equated technology simply with applied science, with the technologist seen as a person who applies scientific insights to solve practical problems or to achieve some human purpose. While most graduates attribute the design of machines to make work easier to technologists, 20% think this task falls within the activity of the scientist. The uncertainties in the potential teachers' minds about technology is highlighted by divergent responses to such statements as 'technology is devising a means of crossing a river without getting your feet wet.' Discussion reveals that technology is, for many graduates in our culture, principally associated with modern, electronic devices. Even greater divergence of opinion is provoked by the statement 'the scientist explores what is, the engineer creates what has not been'.

Despite ambivalence concerning the precise nature of technology, these intending teachers strongly support the inclusion of technology as a component of science education. Further responses reveal that half the applicants consider that science teachers usually fail to locate science studies in the context of everyday life and work. This is presumably a reflection on their own schooling and university education. A similar proportion consider that science education is carried on as though the historical, philosophical, sociological and economic aspects of life were non-existent, but only a third of the sample attributed this deficiency to a lack of understanding of these issues by teachers.

An encouraging aspect of the survey is the idealism revealed by an overwhelming majority of the potential teachers who believe that a science teacher needs to be infinitely flexible, curious and dedicated. There is also evidence of a strong commitment to teach science rather than separate sciences. Perhaps due to the influence of the curriculum developments of the sixties this generation is near unanimous in its belief in the value of guided discovery methods in teaching combined with a substantial majority who reject the proposition that the primary task of science teachers is to transmit knowledge of science. Nevertheless there is a healthy realism in the extent of the appreciation that much secondary school science is fixed and non-negotiable.

There are many indications in the responses of this sample of potential science teachers that STS education may receive a sympathetic response. While there is support for the traditional and classic view that learning science trains the mind and teaches a person to think, importance is attached to solving problems rather than recall of content. Equally support is given to the place of decision-making within the science curriculum together with discussion of social issues and to moral considerations in decision-making. Despite the uncertainties revealed about their own understanding of science there is an almost universal desire to teach science in ways that enable pupils to appreciate that scientific theories are subject to change. There is a matching concern to make science accessible to all young people even if this means paying less attention to the training of future scientists.

Before new teachers start their training, they under-estimate the difficulties which many pupils experience in learning science. Their own academic success and interest in science may be the cause of this mis-judgement. Similarly they do not anticipate children's failure to perceive relevance in much of the science they are expected to learn. There is also widespread ignorance of the negative attitudes towards science which are felt by many young people and of the tendency for existing science courses to attract convergent thinkers rather than those with leanings towards imaginative, open-ended activities.

Prospects

From this survey of science graduates prior to their teacher training it may be concluded that they are generally favourably disposed towards STS education. However, the substantial attention to training for STS teaching which Ziman identifies as a necessity is probably not usually achieved during post-graduate education courses. This is because the one-year course always promotes discussion about priorities for inclusion in the short time available, and while STS gathers momentum, other emerging topics such as science for a multicultural society and science for pupils with special learning needs compete for precious time. Like

Lauwerys before them, teacher educators continue to lament that the majority of graduates still emerge from their science education with minimal knowledge of the history and philosophy of science. Nevertheless, consideration of the ASE Science and Technology in Society materials (SATIS project) and of curriculum units of the Industrial and Commercial Perspectives for Initial Teacher Education (ICP project) are helping to advance STS. Another reinforcement comes through students trialling and evaluating computer software simulations which deal with science and society issues. Therefore, it would appear that there are modest grounds for optimism that Ziman's twenty year time scale for STS to penetrate the system effectively may not be too far out. Even the shortage of science teachers, particularly of physical science teachers, need not hinder the progress of STS education if opportunities for partnership with scientists in industry and community life are developed along lines outlined by Jennings in Science in the Locality, (1986). The climate is probably more propitious than ever before for parents, industrial scientists and techologists and those engaged in local decision-making to share with science teachers in the presentation of scientific issues to promote better understanding on the part of tomorrow's citizens.

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The English School System

Compulsory schooling begins for children aged five and transfer from primary to secondary education is usually at 11+. The General Certificate of Education examinations are taken at 16+ at the termination of compulsory schooling. Students may continue their education in their secondary school or in a college of further education for two more years. At this stage Advanced Level examinations are taken and good passes in three subjects are the norm for university entrance.

This paper relates to science education in the secondary stage of schooling and to teacher training specific to secondary science teachers.

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TEACHER EDUCATION STRATEGY FOR SCIENCE, TECHNOLOGY AND SOCIETY EDUCATION

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Introduction

A well-educated citizenry is as vital to today's world as a global village. Its continued advancement is measured by the quality of education its citizens enjoy, because the quality of education has become the signature by which a community can hope to realise the full potential of itself as well as its members. As the educational needs of a society become increasingly crucial to its survival, specific policies must be established to guarantee their satisfaction within the constraints of the ecology.

Since the individual is central to any open society, quality education naturally originates in the recognition that each person is distinct and unique. Consequently, the privilege accorded to individual differences must logically foster the right of every citizen to an education supportive of personal distinction. A primary characteristic of quality education is its quantitative effect upon each person's increased capacity to control his or her own distiny.

The crucial tools of today's human living include not only the three "Rs" but also those skills that allow the adaptation to the environment - to live with - uncertainty and tolerate ambiguity - and the adaptation of the environment to the citizens - to analyze, synthesize and hypothesize. These "process-oriented" basics cut across subject matter lines to give persons a capacity for response in a range of situations. All this amounts to is to create scientifically and technologically literate citizenry.

All education is the consequence of the response of individuals to enabling experiences - experiences provided to the individual and experiences generated by the individual. The experiences should be provided to the students to enable them to accomplish the following goals:

- To discover and explore scientific phenomena;
- To have some experience with the scientific approach to the rationalization of the results of investigations;
- To develop some understanding of the integrity of the process of scientific investigation and through that the integrity of scientific knowledge;
- To develop some understanding of the process of technological innovation and of the productivity of technology;
- To explore the impact of technology and the products of technology on the quality of life and the quality of the environment;
- To develop the interest, competence, confidence and will to continue to follow, throughout the next half century, scientific and technological developments in areas related to societal concerns;
- To develop the appropriate technology for the sustenance of the society considering all of its aspects;

- To develop the will and confidence to endeavor to participate critically in the formation of decisions in societal matters involving science and technology;

- To develop to some degree an understanding of probability and statistics and the place of both in science and in the analysis and resolution of societal problems;

- To develop familiarity with the role of computers in the extension of scientific knowledge and technological capabilities;

- To develop the confidence to acquire competence in specific areas of technology closely coupled to the fulfillment of his or her professional responsibilities.

These goals emphasize the significance of process and minimize the pressure to overload the academic experience with facts, and in so doing give a person a refreshing degree of freedom in the selection of topics and methodologies of approach.

As educators, what should we do to achieve the above-mentioned goals of Science and Technology education? What strategies should we implement in the education of Teachers in the Preservice and Inservice stages?

Preservice Stage

In a society education is an extremely important enterprise because the final product of this enterprise is a responsive and responsible citizen. The quality of a citizen in terms of moral, ethical, and literal standards, is determined by the educative process that the citizen has gone through. In this educative process at any level, the classroom teacher is the most important person. His or her dedication to the profession, teacher training, depth of subject matters, resourcefulness, readiness to innovate new research findings, and experiment with new educational technologies will help tremendously the educative process.

A model for preservice education of science teachers is suggested elsewhere[2]. We believe that a science teacher should familiarize with all the thirteen components of the suggested model.

Research evidence shows that mastery learning is more effective than the conventional methods. We believe that the combination of mastery learning and the strategies that the model suggests will lead to achieve the goals of education that are stated previously.

The suggested model consists of the following thirteen components:
Business and Industry
Computers
Critical Thinking
Decision Making
Energy and Environment
Future
Handicapped Children
Human Brain
Individualization
Language across Curriculum
Laboratory Safety and Instrumentation
Piaget
Value Education

Inservice Stage

We suggest that the teachers should develop the following mandatory and optional topics.

Mandatory: Basic Mathematics with applications
Graphs; Graphing and Interpretation of graphs
Probability, Statistics and their applications in different disciplines
Measurement and Theory of Errors
Binomial Theorem and its applications

Optional: With the following aspects:
Science, Technology, Sociology, Economics, Politics, relevant student experiments, demonstrations and problem solving, wherever applicable and suitable.

(1) Acid Rain
(2) Radiation
(3) Hypothermia
(4) Earth's Moon
(5) Greenhouse Effect
(6) Smoke Detectors
(7) Blood
(8) Human Body
(9) Comets
(10) Rain Forests
(11) Incandescent Lamp
(12) Solar System
(13) Geothermal Energy
(14) Automobile
(15) Electromagnetic Spectrum
(16) Waste Management
(17) Tides
(18) Cancer
(19) Pesticides and Herbicides
(20) Transportation
(21) Energy
(22) Computers
(23) High Voltage Lines
(24) Environment
(25) Carcinogens
(26) Malaria
(27) Biological Clock
(28) Brain
(29) Physics of sports
(30) Food
(31) Industrial Revolution
(32) Agricultural Revolution
(33) Atmosphere
(34) Lightning
(35) Human vision
(36) Sound and Noise
(37) Meteorology
(38) Nuclear Energy
(39) Atom Bomb
(40) Cybernetics
(41) Laser
(42) Heat Pump

(43) Periodic Table and Elements
(44) Water
(45) Allergy
(46) Camera Optics
(47) Canadian Forests
(48) Crayogenics
(49) Evolution
(50) Science Fiction
(51) Waste Management
(52) Cosmology
(53) Star Wars
(54) Satellites
(55) Gasification of Coal
(56) Nuclear War - Nuclear Winter
(57) Population
(58) Genetic Engineering
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There are 12 provinces and territories in Canada.
The starting age for Kindergarten is 5.
The number of years spent in the school before graduation:

Number of Areas	Early Years	Middle Years	Senior Years
2	K - 6	7 - 9	10 - 11
6	K - 6	7 - 9	10 - 12
2	K - 7	8 - 10	11 - 12
1	K - 6	7 - 9	10 - 12
1	K - 6	7 - 10	11 - 13

There are no common examinations at the end of high school.
The areas where the total number of years is 11, it takes a student 5 years to obtain an Honours Degree.
The areas where the total number of years is 12, it takes a student 4 years to obtain an Honours Degree.
The Province of Ontario is an exception to the above. In Ontario, a High School Graduation Diploma is obtained at the end of Grade 12. To obtain entrance to any of the Ontario Universities, a student has to complete 6 additional courses called Ontario Academic Courses. In Ontario it takes an additional 4 years to obtain an Honours degree.

In Ontario, all Science courses are being revised and being introduced at the Grade 7, 8 and 9 levels in 1987, and subsequent years at other grades. At all levels, a component of curriculum is Science, Technology, and Society (STS). This paper will help Colleges of Education to implement the suggested strategy in preparing teachers for the teaching of science with STS emphasis. In the province I designed and have been teaching a course on STS for the last 9 years, on an experimental basis, at the Grade 13 level. The course could be taught at the First Year University level also.

The IPN (Institute for Science Education) is the research institute in science education with a national function in the Federal Republic of Germany. Through its research work it aims to further develop and promote science education. It is permanently financed by the Federal Government and the Land Schleswig-Holstein, together with the other Länder.

Science and Technology Education and the Quality of Life

This two-volume publication contains 104 papers to be presented at the 4th International Symposium on World Trends in Science and Technology Education to be held at IPN, Kiel, 4–12 August 1987.

Science and technology education will be related to the quality of life with respect to

- the impact on everyday life situations
- decisions a responsible citizen has to make when dealing with (controversial) societal issues
- the impact on future careers, and the potential impact on the (future) products of scientific **and technological research on careers.**

Three working groups will deal with these areas from the point of view of

- science education
- technology education
- science, technology and society (STS).

Volume 1 contains the papers relevant to the theme of Science Education, Volume 2 those relating to Technology Education and Science-Technology-Society.

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